Industrial QUALITY CONTROL

MAY, 1950 VOL. VI, NO. 6

Milwaukee City Hall

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CONVENTION ISSUE

Fourth National Convention
Fifth Midwest Conference
of the
American Society for
Quality Control

Milwaukee Auditorium

Milwaukee June 1-2, 1950

PROGRAM PAGE 58

AMERICAN SOCIETY FOR QUALITY CONTROL

quality control equipment

Your biggest value in quality control equipment ... JO-BLOCKS and ACCESSORIES

Accessory Set No. 47, with 22 pieces, shown above. These pieces include — 12 jaws, 3 adjustable holders, center point, tram points, scriber, 2 triangular straight edges and foot block. Other sets and accessories available.

All Brown & Sharpe Jo-Block Accessories are designed skillfully and made with great care. In every way, they reflect the high precision standards of both Brown & Sharpe and Johansson.

With Jo-Blocks and a few related accessories, you can make a wide variety of precision measuring instruments for checking your quality control gages . . . easily and quickly. For example, a set of 81 Jo-Blocks makes 120,000 of the most accurate measuring tools in the world. Think of it! Accessories extend their uses even further — where else can you find such an extensive array of equipment for assuring the efficiency of your quality control program!

The exceptionally accurate gage shown in the illustration above was assembled in a moment with an adjustable holder, standard Jo-Blocks, and two jaws. There are countless time-saving, money-saving combinations of Jo-Blocks and accessories like this for control of accuracy in tool room work and for the adjustment of production gaging equipment.

No other name means so much in gage blocks as Johansson . . . famous the world over. Write for Illustrated Catalog. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

Johansson
BROWN & SHARPE
JBS

We urge buying through the Distributor

BROWN & SHARPE JBS

"QUALITY IS THE FOUNDATION OF OUR BUSINESS"

• Coined in the days of the original Cyrus H. McCormick, this motto has guided our production policy for scores of years.

So it is natural that quality control is an important part of our daily thinking.

In 1949, we enlarged and extended our system of individual quality control in all plants. This expansion continues in 1950.

The X-Ray machine shown here is an interesting piece of quality control equipment. This 1,000,000-volt machine in Harvester's Manufacturing Research Department "looks through" 5½ inches of steel to examine the structure of fabricated parts. To protect operators and others from secondary radiation from its powerful tube, the machine is housed in a room with concrete walls 18 inches thick. Control is from a panel outside the room.

This is a far cry from the rule-of-thumb days when hitting a piece of steel with a hammer and judging its quality by sound was the more or less accepted standard of quality control in industry generally.

INTERNATIONAL HARVESTER

180 NORTH MICHIGAN AVENUE CHICAGO 1, ILLINOIS

Precisely so

TIME WAS, when measurement was largely a matter of opinion—when a rod equalled the combined length of the left feet of 16 men standing in line . . . a yard, the length of an outstretched arm . . . an inch, three barley corns taken from the center of the ear and placed end-to-end.

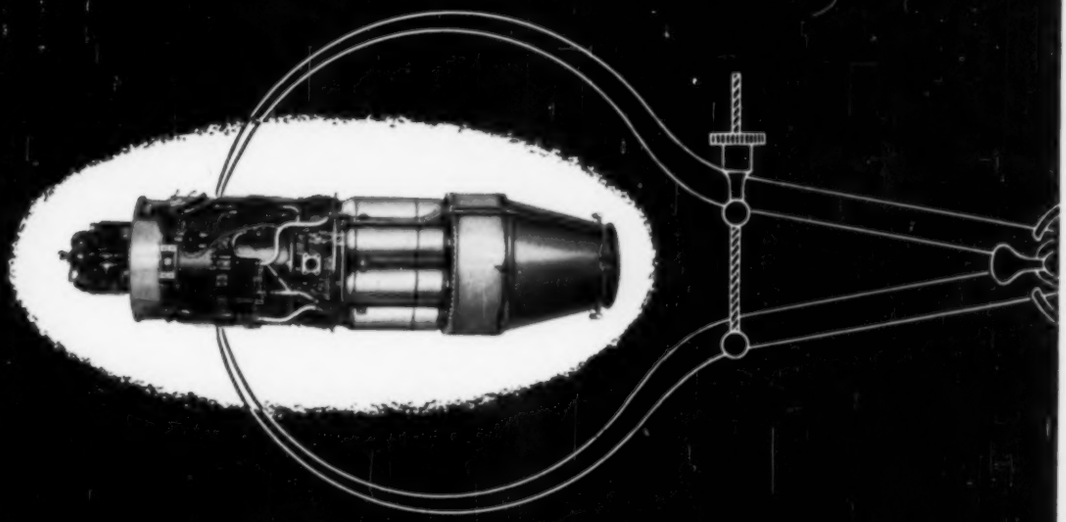
But modern mass production demands *exact* measurement—that even the smallest part be made precisely so, to an accuracy far beyond anything thought possible a bare fifty years ago.

Ford, pioneer of automotive mass production, has likewise pioneered in the development of ever-better means of accuracy in measurement. Today over 38,000 precision gauges are used in the Rouge Plant alone, many of them measuring to within one ten-thousandth of an inch. And other measuring and checking devices, such as the profilometer, work in millionths of an inch to give you more value, more quality in the Ford-built products you buy. For accuracy builds quality, and . . .

. . . *Quality comes FIRST at Ford's!*

FORD MOTOR COMPANY

BUILDERS OF FORD, LINCOLN AND MERCURY CARS . . . FORD TRUCKS, FARM TRACTORS, INDUSTRIAL ENGINES AND MOTOR COACHES



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Republic F-84 Thunderjet
Grumman F9F-3 Panther
Northrop F-89A Scorpion
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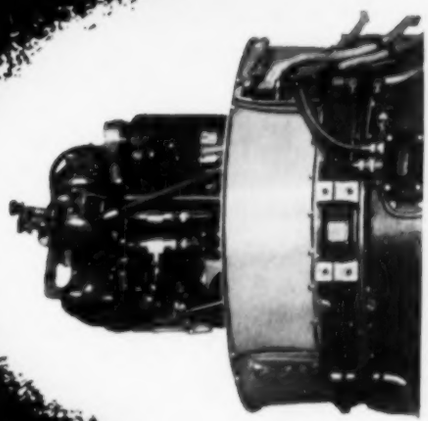

J35 Axial-flow Turbo-Jet

Allison

Builder of axial and centrifugal flow turbine engines

DIVISION OF GM GENERAL MOTORS

Indianapolis, Indiana

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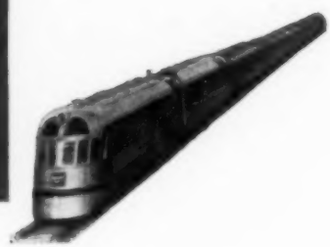
by transportation men for
LOWER-COST OPERATION
HIGHER AVAILABILITY



TRUCK TRANSPORTATION

Pacific Intermountain Express has standardized on Cummins Diesels for its long-line operations and uses a total of 132 Cummins-Powered freight trucks. Cummins Diesels power more heavy-duty trucks than all other Diesels combined.

RAIL TRANSPORTATION

Chicago, Burlington and Quincy is using Cummins Diesels to drive generating sets on their streamliners and has been using these profit-making engines for more than 15 years. 19 other leading Class I railroads are using Cummins Power in locomotives, motor cars, motor trains, maintenance-of-way equipment, switchers, and auxiliary power applications.

CUMMINS DIESEL

BUS TRANSPORTATION

The top performance of Cummins Diesels in railway applications and freight trucks is being duplicated in the bus industry. For example, Queen City Coach Company, one of the largest independent operators in the United States, reports top economy from Cummins-Powered buses on southeastern highways.

***50 to 550 HP* Highspeed Diesel Engines**

for: On-highway Trucks • Off-highway Trucks • Buses • Tractors • Earth-Movers • Shovels • Cranes • Industrial Locomotives • Air-Compressors • Logging Yarders and Loaders • Drilling Rigs • Centrifugal Pumps • Generator Sets and Power Units • Work Boats and Pleasure Craft

Statistical Quality Control used for many years in all production departments at the Cummins Factory in Columbus, Indiana, ensures maintenance of the close tolerances required for the precision manufacture of Cummins Diesels.

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EXPORT: CUMMINS DIESEL EXPORT CORPORATION • COLUMBUS, INDIANA, U. S. A. • CABLE: CUMDIEX

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Builds Quality Cars through Quality Control!

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OLDSMOBILE DIVISION GENERAL MOTORS CORPORATION

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—USE THE

Allis-Chalmers HD-5G and Tracto-Shovel Interchangeable Attachments*

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JUST THE RIGHT SIZE—to efficiently handle a wide variety of jobs. Has 11,250 lb. of properly balanced weight (tractor bare) . . . 40.26 drawbar hp. provided by the smooth-running, economical, 2-cycle GM Diesel engine—every down stroke a power stroke!

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BUILT-IN SAFETY AND CONVENIENCE—Easier steering and shifting with convenient controls, full vision. Cushioned seat, wide arm rests. Operator gets more done because it's easier to do more!

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Here's the man who knows.

After 30 years of classifying cotton, his sensitive fingers judge samples received by Johnson & Johnson for quality, length of fiber, and freedom from foreign matter.

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Yes, 40% of the samples are judged as "not good enough . . ." for the cotton used for Red Cross* Absorbent Cotton *must exceed* the minimum requirements set by the U.S. Pharmacopoeia.

12 more tests insure quality!

And, even after the cotton is accepted, nearly 25% of the original weight of the bale is lost through processes of washing, carding, combing and refining.

After the finished product has been packed, samples are subjected to 12 additional tests to be sure quality requirements have been maintained during manufacture.

It's only by these strict procedures of careful selection and processing that the raw cotton becomes the softest, whitest, most absorbent and long fibered sterile product worthy of bearing the name Johnson & Johnson Red Cross* Absorbent Cotton.

Is it any wonder that, of those who use absorbent cotton, 7 out of 10 use Johnson & Johnson Red Cross* Absorbent Cotton?

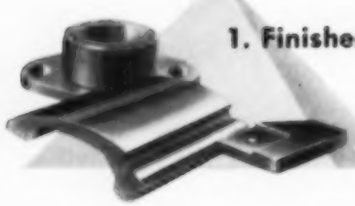
*No connection whatever with American National Red Cross.

The most trusted name in surgical dressings . . .

Johnson & Johnson

Customers state... **Oilite**

Products *yield pyramidal savings...*



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2. Heavy-duty oil-cushioned, self-lubricating bearings

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PLUS

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PRODUCED UNDER STATISTICAL QUALITY CONTROL

SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.

CONTACTS
High current capacity . . . Low voltage drop . . . No additional solder required.

SCINFLEX★ ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

offer you this IMPORTANT EXCLUSIVE FEATURE . . .

. . . PRESSURE TIGHT SOCKET CONTACT ARRANGEMENTS!

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★ **SCINFLEX** dielectric material is a new development that assures unequalled insert performance. It is available only in Bendix-Scintilla Electrical Connectors.

PLUS ALL THESE OTHER FEATURES

- Moisture-proof
- Radio Quiet
- Single-piece Inserts
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- High Insulation Resistance
- Easy Assembly and Disassembly
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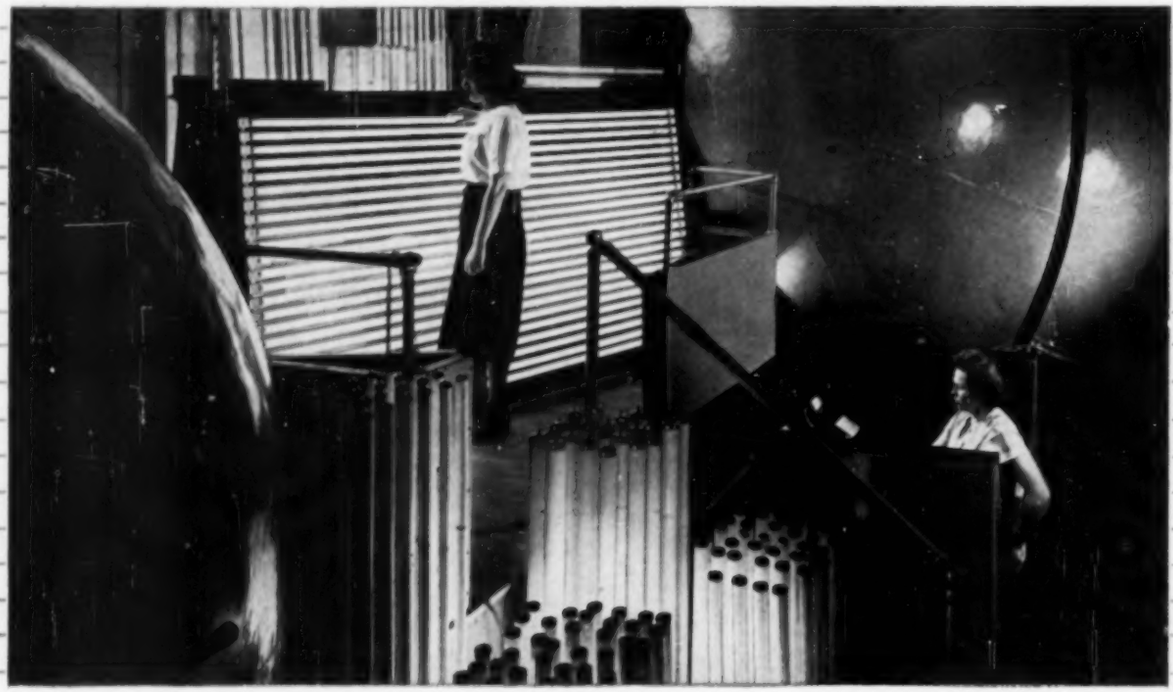
QUALITY CONTROL DATA SHEET

SYLVANIA FLUORESCENT LAMPS



EVERY 60 MINUTES, QUALITY OF SYLVANIA FLUORESCENT LAMPS IS CHECKED WITH BIG PHOTOMETER

To insure lamps that are unsurpassed, Sylvania quality control engineers take *hourly checks* of production line lamp samples in this huge 15-foot diameter Photometer! This high-speed unit allows fast, accurate checks on light output and electrical characteristics. It serves to *keep* Sylvania Lamps "The Best Light In Sight!"

In addition, samples of *each day's output* are tested against lamps of other brands—further insuring that the Sylvania Lamps shipped everywhere are unbeatable! This supervision of lamp quality consists, too, of testing light output at various stages of lamp life . . . of determining voltage and current characteristics.

This huge unit is just one of many *extra-quality controls* employed at Sylvania to make sure *Sylvania Lamps are the best buy in fluorescent illumination!* That's why they give *far more light*, have *longer life* than ever before!

For full information on the entire Sylvania line, write Advertising Dept. L-8510, 500 Fifth Ave., New York 18, N. Y.

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quality control

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Du Mont Quality Control extends through the entire manufacturing process, guarding against the possibility of defective parts or workmanship at every point.

Du Mont vigilance in manufacture and testing means Du Mont television equipment performs better and lasts longer... means finer television for America.

We invite you to see the
Morey Amsterdam Show
...Thursday Evenings
...Du Mont Television Network

DUMONT *First with the finest in Television*

Copyright 1950, Allen B. Du Mont Laboratories, Inc.

Allen B. Du Mont Laboratories, Inc. Television Receiver Div., East Paterson, N. J., and the Du Mont Television Network, 515 Madison Ave., N.Y. 22, N.Y

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for world-wide export service

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for national distribution of replacement automotive parts

CALUMET STEEL—for Gold Crown steel fence posts, steel tubing, reinforcing bars, steel shapes, channels, angles, bars, etc.

DETROIT GEAR—for transmissions and precision parts

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FRANKLIN STEEL—for steel fence posts, reinforcing bars, steel shapes, channels, angles, bars, etc.

INGERSOLL STEEL—for farm implement parts, special steels, automotive stampings, domestic furnaces and Koolshade screens

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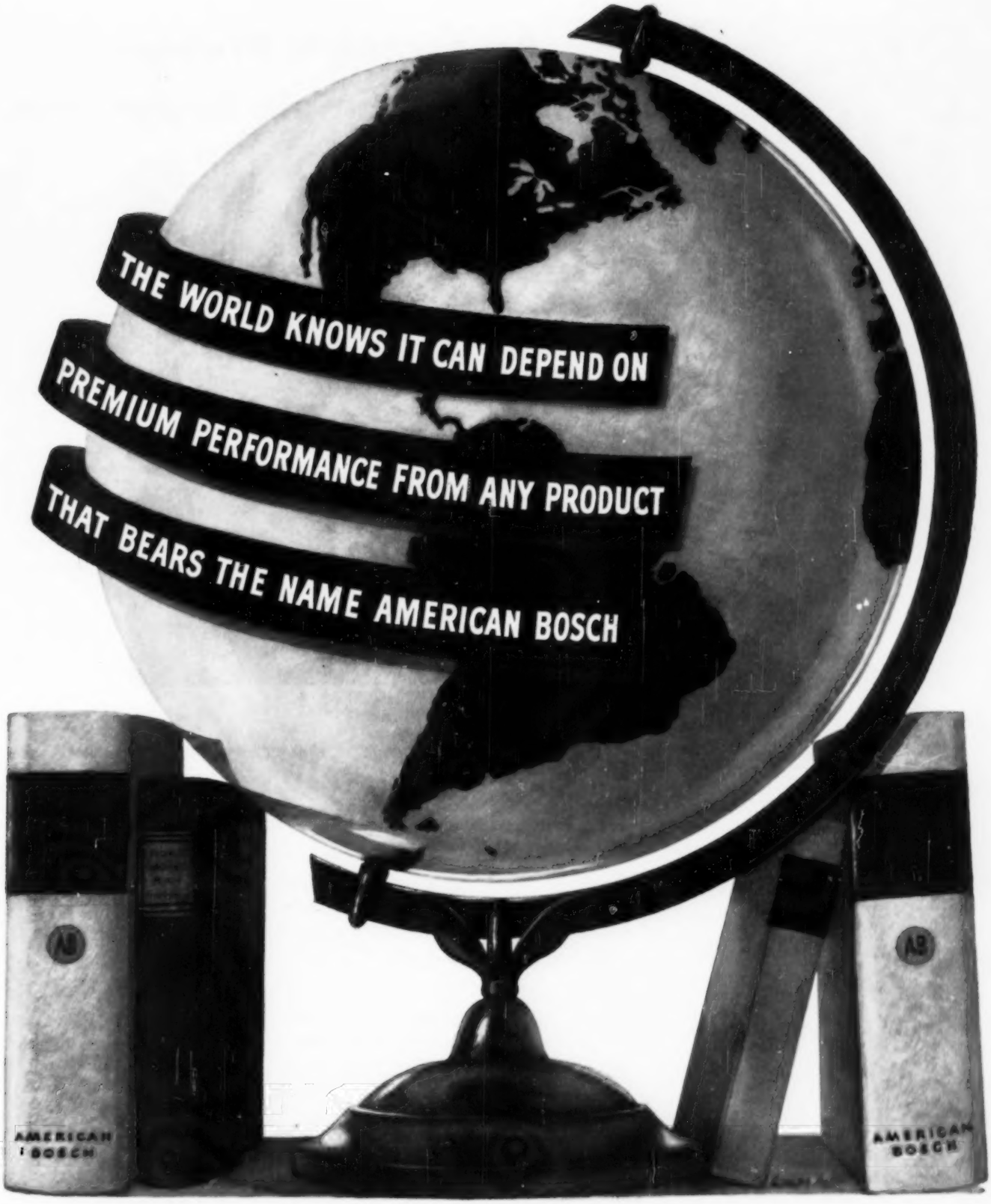

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Factory in Springfield, Massachusetts • Service the Whole World Over

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This refrigerant pump eccentric shaft presented a real problem to engineers of one of America's leading refrigerator manufacturers. For units of ¼ H.P. and under, carbon steel met all machining and heat treating requirements without difficulty. On larger units, however, distortion encountered in hardening treatment resulted in excessive reject losses.

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INDUSTRIAL QUALITY CONTROL

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IQC NEWS SUPPLEMENT

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Chicago 38, Ill.

Cost of Back Issues

Back issues, comprising Volumes 1 through V are available at $8.00 per volume, including the Index. Individual issues at $1.50 each.

"The business philosophy of our operations divides itself broadly into two categories: (1) we must manufacture our products at *highest quality possible* and (2) through research create new products which fit a need. Only by following these principles can any business grow, enjoy proper earnings and maximum employment at high wages."

Ernest Mahler

Executive Vice-President

Since 1872, manufacturers and developers of quality pulp and paper products.

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NEENAH, WISCONSIN

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Industrial Quality Control

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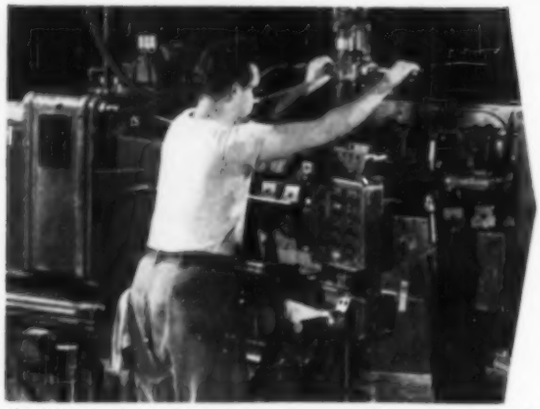
Welcome A.S.Q.C. Convention

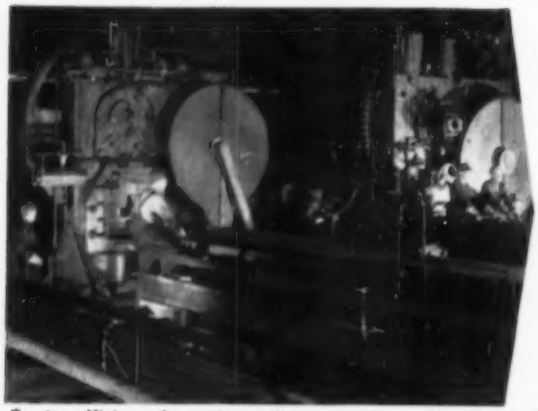
The lights go up in Milwaukee's City Hall Tower on June 1 & 2, 1950

Milwaukee Journal Photo

1. Statistical methods in physical inspection of Ladish fittings improve uniformity of the product.



2. Applying quality control principles to machining assures predictably closer tolerance work.



3. Greater efficiency in cutting mults to length is achieved through statistical quality control.

4. Forging operations controlled by statistical methods result in more uniform physical dimensions.

HOW STATISTICAL QUALITY CONTROL METHODS ASSIST IN GIVING LADISH

Controlled Quality

FITTINGS AND FORGINGS INCREASED RELIABILITY

Illustrated at left are typical inspection and production operations in the Ladish plant which have been made more efficient by the application of statistical quality control.

This statistical method of quality control is incorporated into the Ladish Controlled Quality program wherever it demonstrates an ability to maintain existing standards effectively or indicates an opportunity of raising the over-all quality of operations to higher planes. It functions as one of the vital tools which build maximum reliability and dependable performance into every Ladish Controlled Quality fitting and forging.

LADISH CO.

CUDAHY, WISCONSIN
(MILWAUKEE SUBURB)

The Application of Quality Control To Administrative Problems

CHARLES A. BICKING

Hercules Powder Company

INTRODUCTION

The impact of government control in an effort to bring about economic stability is one of the outstanding influences on industrial management today. It is an important factor in the new tendency in industry to look upon internal control as an inherent part of management rather than as a casual tool. The development of statistical controls in all fields of management holds the greatest promise for fundamental gains in managerial control. It may be a decisive factor in the preservation of private enterprise. Quality control, through the application of one of its simplest tools, the control chart, is capable of contributing substantially to this development.

Business and economic data must be analyzed by statistical methods if their collection is to be justified. Graphic representation is known to be a most effective tool in presenting the resulting information. The control chart has something to contribute to better use of administrative data because it is simple in use, economical of effort, and effective in results. No small part of its contribution is the way its use affects thinking about variability in data. The concept of normal or acceptable limits to variation provides a basis for decision and action that often is absent in other methods of handling data.

The accumulated weight of evidence is reinforced by the ability to state the significance of a difference in terms of definite probabilities. The separation of unusual from usual occurrences is reduced to a methodical procedure rather than being left to judgment which is subject to personal bias and human error. When the weight of evidence has not accumulated, or accumulates slowly, the sensitivity of the control chart contributes to much prompter and more accurate assessment of a situation than otherwise would be possible.

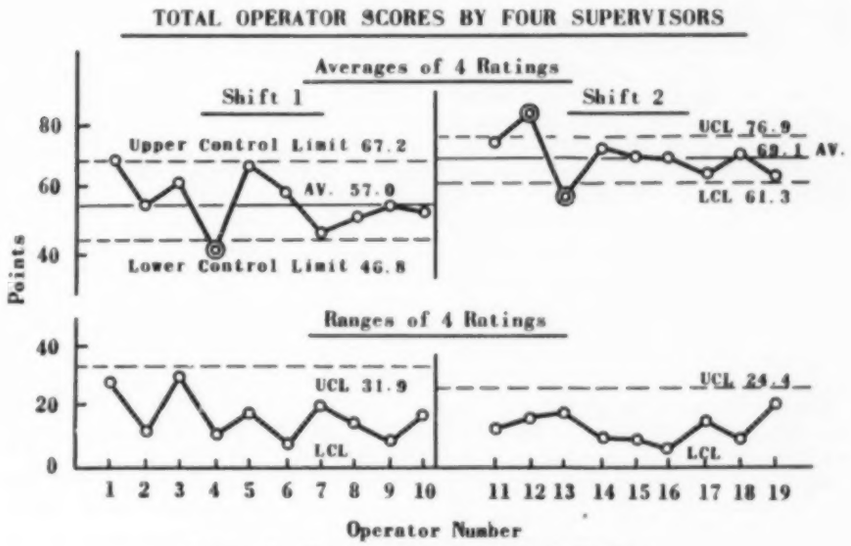


Figure 1—**Control Chart of Merit Ratings**

The examples which follow describe the application of different types of control charts to management problems of widely differing character.

MERIT RATING OF PRODUCTION PERSONNEL

The first example deals with the scores obtained by the application of a merit rating plan to production personnel in one small manufacturing operation. The plan involved ten characteristics which were determined to be important for satisfactory performance of work in the department. An individual was given a score of 1 to 10 on each characteristic depending on whether he possessed the characteristic to a slight, moderate, or high degree. The total scores for all characteristics were used in this analysis.

The workers were assigned permanently to one of two shifts but the four supervisors rotated between the two shifts. Therefore, over a period of time each supervisor had direct contact with all of the workers. Consequently, a series of four ratings for each man was made, one by each supervisor.

For the first control chart, Figure 1, the four ratings for each operator were used as a sub-group. Control limits were calculated separately for each shift based on the grand average and average range of these subgroups. The ranges for both shifts are all within the control limits, indicating substantial agreement among the four raters in every instance. The narrower limits for Shift 2 indicates that for some reason the agreement of supervisors is better concerning the abilities of individuals on Shift 2. The fact that the average of all ratings for Shift 2 is significantly higher than the average of Shift 1 confirms the conclusion that may be drawn from this agreement that the labor-management relationship of Shift 2 is better.

The score for Operator No. 4, Shift 1, is out of control on the low side. This indicates that this individual is not turning out a satisfactory grade of work, based on the performance of his co-workers. Action was taken before another rating was made to bring this to the operator's attention and to assist him in improving his performance.

The score for Operator No. 12,

Shift 2, is out of control on the high side. This indicates that he is doing a superior job. He is definitely in line for promotion or for an increase in responsibility and earnings.

It is concluded, by the same kind of reasoning, that Operator No. 13, Shift 2, is not performing as well as others in his shift. However, since his rating is still above the average of Shift 1, the reason for his low rating may be a matter of poor job adjustment rather than lack of merit. It was suggested that he might be assigned to Shift 1 with more satisfaction to all concerned. Similar reasoning indicated that Operators No. 1 and No. 5, Shift 1, might do even better work as members of Shift 2.

It has been suggested that the higher average score for Shift 2 may reflect better all-around feeling within that group. That leads to the use of the second control chart, Figure 2, to analyze the raters themselves, rather than the operators who were rated. In this second chart, the individual scores of operators on both shifts have been arranged by rater.

The scores for the operators on Shift 1 are plotted first, followed by the scores for Shift 2. The control limits for each rater were calculated independently by arranging his scores in groups of four. The averages and ranges of these sub-groups were used to calculate limits for the individual scores.

The individual rating out of control on the third supervisor's chart is in line with lack of control for Operator 4, on the first chart. However, the low individual rating on the fourth supervisor's chart does not conform with the other ratings of the individual it represents. This score may be explained as an unfair rating due to prejudice or to misinterpretation of the individual's ability. The chart shows, moreover, that the average score by the fourth supervisor is significantly lower than the averages of the others. This indicates that his ratings are too severe. This should be looked into and if it is found to have basis in his attitudes or in his techniques of rating, these should be corrected.

The other supervisors agree well. The fact that the average score of the second supervisor is centered between the adjoining two averages and that his control limits are narrower indicates a careful rating job. This may reflect a superior managerial ability.

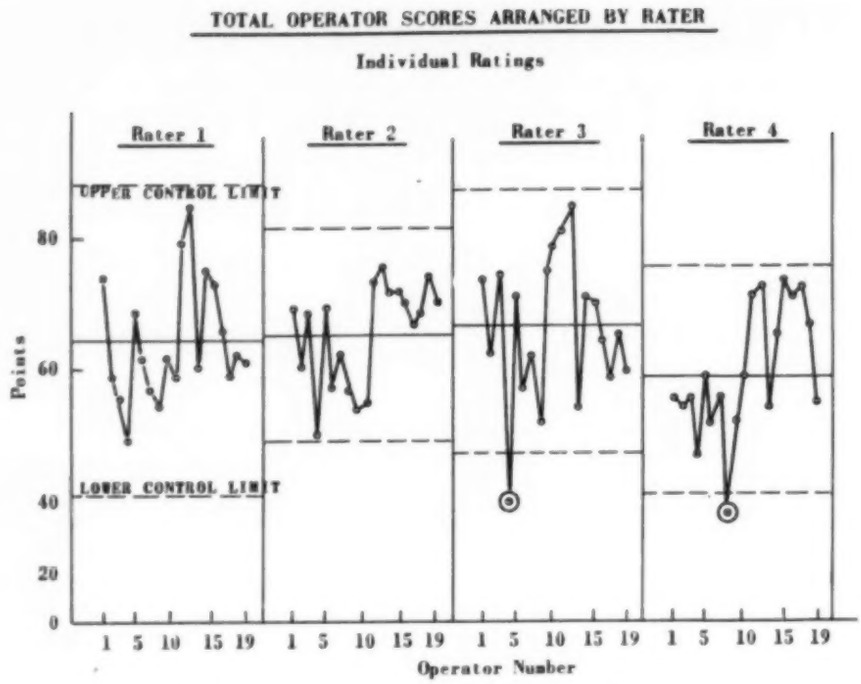


Figure 2—**Control Chart of Merit Ratings**

TOTAL PRODUCTION COST

The control chart in Figure 3 may appear to be a little unusual. However, the first portion of it simply represents the application of control chart limits calculated in the usual way to the downward trending production cost of a manufactured material. Each point represents a monthly cost per 100 lb. of material produced.

The unmistakable downward trend during the first few months was due to a program of cost reduction including a control chart system for control of quality during production. In December of the first year, there seemed to be a temporary halt in the reduction of costs but the next two months carried on the trend. In March, however, another upward swing in cost occurred and the question was raised again whether a change in trend had occurred.

Interest in change or impending change is at the root of management's interest in economic data. A statistical technique which is highly sensitive to changes in trend can be

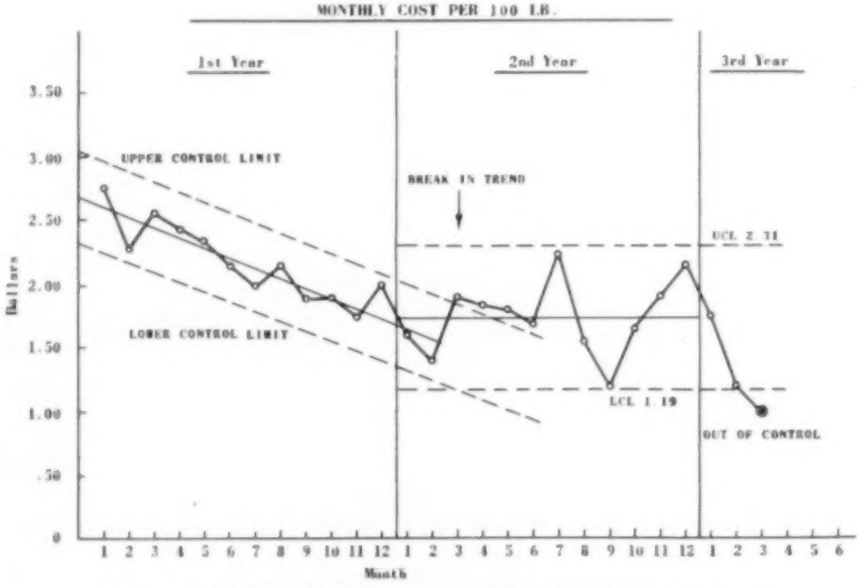


Figure 3—**Control Chart for Trend in Manufacturing Cost**

a very acceptable and well appreciated tool. The use of confidence limits (or, in this instance, of control limits) on a trend supplies just such a very sensitive indicator of change.

In order to place the limits, it was first necessary to determine the straight line which fitted the trend. This was done by the method of least squares, which is a technique widely used in problems of correlation and regression. Next, the data were arranged in chronological order, as in Table I.

TABLE I—Data for Trend in Manufacturing Cost

Month	Cost per 100 Lb.	Moving Range
1	$ 2.75	
2	2.30	$ .45
3	2.55	.25
4	2.45	.10
5	2.35	.10
6	2.15	.20
7	2.00	.15
8	2.15	.15
9	1.90	.25
10	1.90	0
11	1.75	.15
12	2.00	.25
13	1.60	.40
14	1.40	.20
Totals:	$29.25	$2.65
Averages:	$ 2.09	$ .204

Since the variation which is of interest is the difference in cost from month to month, a logical sub-group for calculating control chart limits is two months' figures. Furthermore, the amount of data is so scant that most advantageous use of the data is imperative. The most advantageous way of using these data (that is, the way that will give the largest number of sub-group ranges) is to employ moving ranges. The moving range is simply the consecutive difference from month to month. The average moving range is used in the control limit calculations. A further point is that it is desired to plot individual monthly costs so that control chart limits for individuals rather than for averages are required.

Two standard deviation limits for monthly cost = A Trend Point $\pm$ $2/3 \cdot A_2 \cdot \overline{R} \cdot \sqrt{2}$ = Trend Point $\pm$ (1.77) (.204) = Trend Point $\pm$ .36.

Limits with the same meaning might also have been calculated from the least squares data as the residual variance about the trend line. For this example the latter more involved computation gave exactly the same limits as the control chart method.

When the plus and minus limits are measured vertically from points on the trend line, it is found that all fourteen months on which the trend is based are within the limits. However, March of the second year is outside the limits. This confirms the suspicion that the trend was broken during that month. This chart was sensitive enough to verify the change in trend in its very first month. The evidence supplied by the March data was borne out in later months.

The problem now revolves around determining the new level or trend of costs. After the first half of the year, major equipment changes were made which disrupted production schedules and produced a very erratic cost picture. This was in spite of a continual increase in output. In any event it would have been unlikely that the new level could have been established satisfactorily in much less than a year. However, when the second year's data were used to calculate control limits by the moving range method, it was found that though the limits were wide, control existed.

The condition of control lasted through February of the third year. By that time the new equipment was all installed and a new program for further reducing costs was under way. In March costs again exceeded a control limit, this time in a downward direction. This indicated either the existence of a new downward trend or the establishment of a new, lower level of cost with the improved equipment.

Not only was management provided with justification of the capital expenditures but also prompt information was available for any necessary or desirable modification in prices. New limits could be calculated at the end of the third year to measure the nature and extent of the change in production costs.

INDUSTRIAL LOST-TIME INJURIES

Another example of the use of the control chart technique, this time what is normally called a chart for number of defects, involves the study of the accident experience of an industrial company.

Accidents, by the very connotation of the word, are preventable. However, though they are not inevitable, a certain number may be expected in view of the nature of the tools and machines with which men work. Other factors which contribute to the few accidents which we may expect are the present state of the art of using production machines safely and the willingness of individuals to abide by established safety practices.

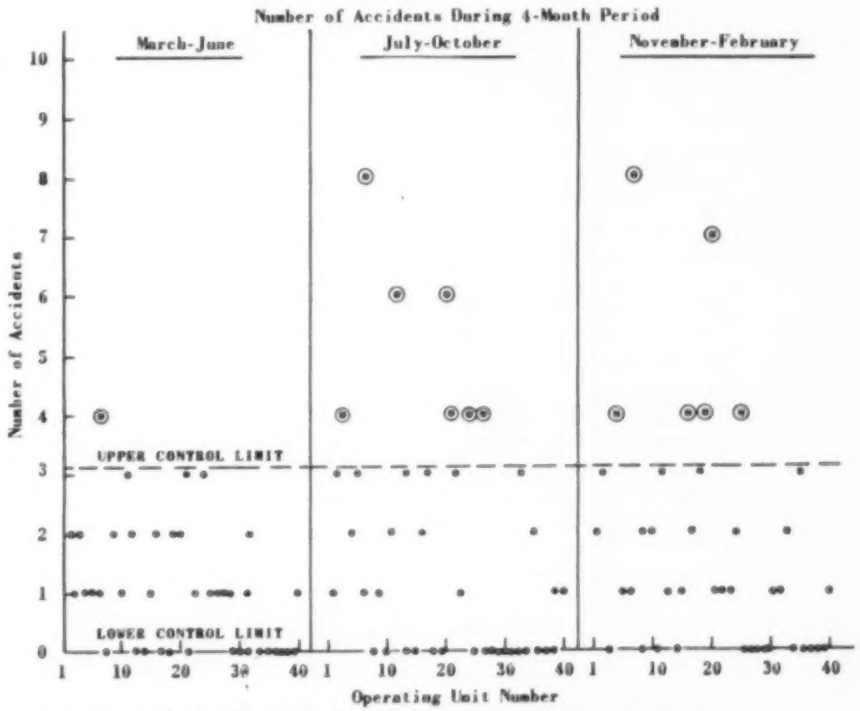


Figure 4—**Control Chart for Number of Lost-Time Accidents**

It is desirable to know what the accident expectancy is in light of the control which has been achieved over the three contributing elements. If it can be determined what reasonably is to be expected, variations due to specific causes may be spotted. Corrective measures may be applied where they will be most effective.

On the basis of actual safety records, the number of accidents which may be expected normally through the operation of chance causes may be determined. The chance occurrence may be separated from extraordinary conditions whose causes justify taking extraordinary corrective action. This may be done by carefully comparing the safety records of various operating units by means of a control chart.

Figure 4 is a control chart for the number of lost time accidents in forty operating units of a manufacturing concern. The value plotted on the chart is the total number of lost-time accidents per unit during a four month period. Three periods, which cover a whole year's experience, are shown.

Table II shows the data from which the limits were calculated.

The average number of injuries for all forty plants during the first period was substituted in the formula for two standard deviation limits. The limits are given by the average number of injuries plus and minus twice the square root of the average number of injuries, or 3.1 and 0.

In the first third of the chart only one point fell above the upper control limit. This indicated that only for Unit #7 was the number of accidents (4) during the period greater than should have been expected. It signified that, relative to the accident experience in the other units, this was the only place where accidents got out of hand. It implies that only for this plant would one be likely to find readily causes which might lead to similar poor results in the future. Of at least equal importance is the implication that as far as the other units are concerned, we may expect no better record in another period unless basic working conditions or attitudes are changed. It is reasonable to expect improvement in the record of Unit #7 if the reason for lack of control is explained. Also, if continued care is given to safety in the other plants, their records should be about the same in succeeding periods.

TABLE II—Number of Lost-Time Injuries—Data and Calculations

Unit	Number of Accidents			Unit	Number of Accidents		
	March-June	July-October	November-February		March-June	July-October	November-February
1	2	1	2	21	3	4	1
2	1	3	3	22	0	3	1
3	2	4	0	23	1	4	1
4	1	2	4	24	3	1	2
5	1	3	1	25	1	4	4
6	1	1	1	26	1	0	0
7	4	8	8	27	1	0	0
8	0	0	0	28	1	0	0
9	2	1	2	29	0	0	0
10	1	0	2	30	0	0	0
11	3	2	0	31	0	0	1
12	2	6	3	32	1	0	1
13	0	3	1	33	2	3	2
14	0	0	0	34	0	0	0
15	1	0	1	35	0	2	3
16	2	2	4	36	0	0	0
17	0	3	2	37	0	0	0
18	0	0	3	38	0	0	0
19	2	0	4	39	0	1	0
20	2	6	7	40	1	1	1
				Totals:	42	68	65
				Averages:	1.05	1.70	1.625

2 σ Control Limits for number of Lost-Time Injuries $= \overline{p}n \pm 2\sqrt{\overline{p}n} = 1.05 \pm 2\sqrt{1.05} = 1.05 \pm 2.05 = 3.1$ and 0

Since this first period represented a fairly satisfactory, though not perfect, condition, the same limits were extended for use in later periods. However, just at this time, a major expansion in the output of all of the units occurred, necessitating the employment of large numbers of new, inexperienced hands. The marked increase in the average number of lost-time injuries and the alarming increase in the number of units out of control are accounted for by this situation.

During the second period seven units were above the control limit (Nos. 3, 7, 10, 19, 20, 22 and 27). During the final period, six plants were out of control (Nos. 4, 7, 16, 19, 21 and 26).

The usual type of accident frequency record would have shown that the accident rate increased alarmingly during the latter periods. The control chart shows something more. It indicates exactly which of the plants having a higher accident rate than usual warrant alarm. It provides the basis for strenuous action to prevent recurrence of the poor showing. All the educational and technical resources of the safety division may be trained on those units where the problem is unusually serious.

FORECAST OF SALES VOLUME

The final example concerns the use of a control chart to assist in forecasting monthly sales volume. Forecasts were being made by individual products in each sales district and forwarded to a central point for production planning. Considerable dissatisfaction had been created in the production division by frequent large discrepancies between forecast and actual sales. Sales much in excess of forecast required radical adjustments in production schedules and often resulted in higher production costs. When much more material was produced than was sold, the problems of storage and of inventory values became important. The production division raised the question whether control charts which had been found useful in production control could be used to smooth out forecasting irregularities.

The obvious reason for putting forecasting in the hands of the district sales offices was the familiarity of the men in the field with the market. However, it was possible that a simple graphic tool which would provide them with a continuing picture of both sales and forecasts would make their job easier and, at the same time, more reliable.

Consequently, the sales in thousands of pounds by months for a year were used as a basis for calculating a center line and upper and lower control limits for every product in each district. The method of moving ranges was used to arrive at "one sigma" limits for monthly sales. In instances where the sales volume was steady, a normal control chart with a central line at the average sales value was used. For new products, or in instances where the sales volume was on the increase or decrease, a trend line was calculated and the control limits were measured off vertically from the trend line. In Figure 5, the chart for Product A is for the established type of product and the one for Product B shows how an increasing trend was handled.

The center line of the chart was called the "Basic Forecast". The control limits used should bracket a majority of the monthly sales totals (actually, the proportion is 68.27%) as long as conditions remain normal. In other words, unless new business is obtained or existing customers are lost, most monthly sales totals should lie between these limits. The sales curves for January through July for Products A and B show that this is actually true. For the first five months, forecasts were made according to the old system. It is observed that forecasts outside the control limits on either the low or high sides missed actual sales by large margins. Conversely, forecasts which fell within the limits corresponded very well in all but one instance with actual sales. In June and July, forecasts made in conformance with rules for use of the control charts matched actual results very closely.

The rules set up for using the charts are not complicated. The basic forecast for a given month is the grand average or trend point for the month, depending on the product pattern. Sales experience within the most recent months should be studied to locate an "adjusted forecast". The adjusted forecast will normally be within the control limits. However, the basic forecast may be increased or decreased by the sales manager of the district to an adjusted forecast outside the control limits for good reason, such as clearly foreseen increases or decreases in orders. The evidence of good control of forecasts when this formula is followed tends to dampen the natural ardor of the salesman who predicts new accounts too early or at too high a level.

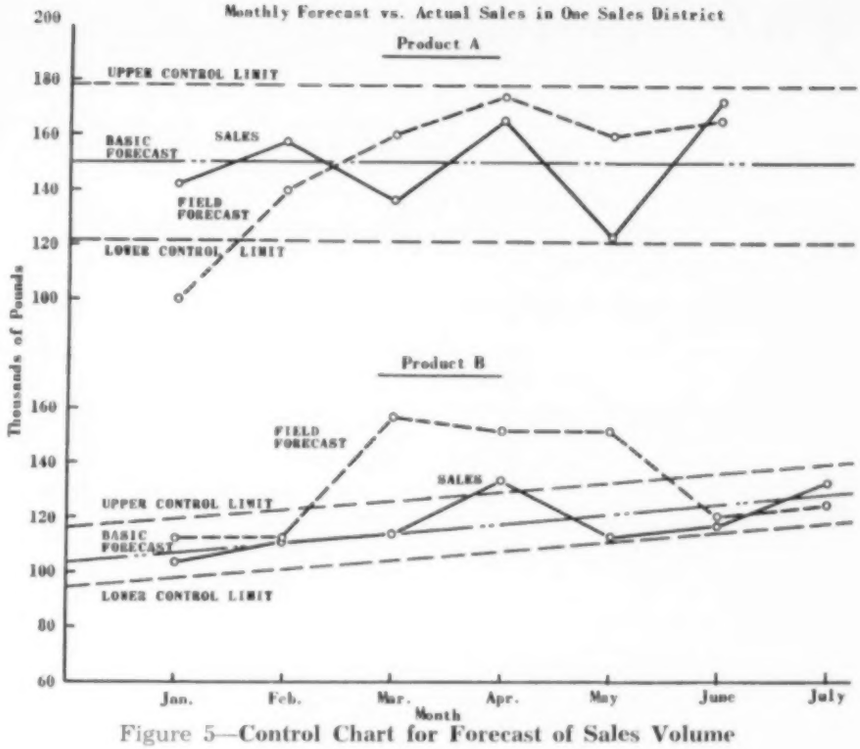


Figure 5—**Control Chart for Forecast of Sales Volume**

If actual sales fall inside the basic forecast limits or within the same range of an adjusted forecast, the forecast is considered to have been satisfactory. The same limits will be extended for another month's forecast. However, if actual sales fall outside the limits, a new calculation will be made, including the new data.

In the first few months of use, this procedure proved its ability to help bring forecasts and sales closer together. The close cooperation between sales and operating departments necessary to bring this about made for better relationships. The sales department felt better justified in making its estimates. The production department was able to level the production schedule to a satisfactory degree.

CONCLUSIONS

These are only a few of the many kinds of administrative problems to which the control chart technique may be applied profitably. It may be said that almost any kind of administrative data lends itself to this easy, productive kind of analysis. Almost the only limitation is that the order in which the data were obtained must be preserved or the source from which the data arose be identified.

APPENDIX

Some of the Suggested Fields for Application of Quality Control in Business Management

Absenteeism
Budgetary and Cost Accounting Records (Current Ratio, etc.)
Clerical Work Standards
Cost Analysis
Credit Conditions (Overdue as Percent of Total Receivable)
Customer Sales
Economic Indices
Error Rates
Estimating Accuracy
General Business Conditions
Inspection Standards
Inventory Relationships and Discrepancies
Manufacturing Tolerances
Merit Ratings
Office and Sales Expense
Overtime Pay
Personnel Performance
Personnel Placement
Production Rate
Production Time Lost
Quality Acceptance by Customers
Sales by Territories
Sales by Salesmen
Sales by Lines
Sales by Totals
Sickness Rates
Traffic Data
Training Guide
Wage Structure

The Air Force Approach To Statistical Quality Control *

O. C. GRIFFITH

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BACKGROUND

The Air Force is big business. In value of assets, number of employees, and world wide coverage, it is one of the biggest businesses in the world. Our stock in trade is air power; our stockholders are the most demanding people on earth—the American public. They demand (and they are going to get) the maximum in air power at the lowest possible cost. The key to efficiency is good management. As we all know, statistical quality control is one of the more powerful tools of scientific management; it is particularly effective in the administration of a large inspection organization, such as the Air Force's, which is vitally concerned with the quality of the products it accepts. The Air Force has come to realize that Statistical Quality Control provides techniques and administrative controls that are indispensable to the economical and efficient management of its inspection activities.

The Air Force has been the most recent of the Military Services to recognize the benefits of SQC—probably because of the nature of the equipment we use, and because SQC inspection procedures were for a long time considered to involve risks which have no place in the aircraft industry. No one was willing to take a chance on any defective material getting into a plane. Now, of course, we realize that some risk is inherent in practically all inspection. We realize also that our best inspection efforts in the past were not good enough; these efforts involved risks of unknown magnitude and at the same time failed to provide accurate and systematic procedures for quality evaluation. A few abortive attempts were made by various individuals in the AF inspection organization, during the war, to set up an SQC program. Some of our contractors used sampling to a limited extent, notably in connection with the magnetic inspection of aircraft bolts. A few examples of the use of process control charts are on record. However, the entire subject was all but forgotten with the cessation of hostilities.

Late in 1945, the emphasis in all of the armed services shifted from defeating the enemy in combat to defeating waste and inefficiency in our own organizations. One step in this program was the assignment of several hundred officers to graduate study in various civilian universities; some officers were trained in business administration, others in production engineering and industrial management. Several of us had the opportunity of studying SQC under Professor E. L. Grant at Stanford. I was one of those who had this good fortune. Upon completion of my work at Stanford in 1948, I was ordered to the Inspection Section (now the Quality Control Division) of the Air Materiel Command at Wright-Patterson Air Force Base. My assignment was to organize and develop an SQC program for the Air Force. During the early days of my work in this new field, I am certain that I encountered all the pitfalls and obstacles of which Grant and other writers warned us. In order to understand some of these problems, I think it would be well to digress momentarily to outline both the AF inspection organization and its basic operating policy.

The Quality Control Division at the Wright-Patterson Air Force Base is a staff organization of the Air Materiel Command. Some one hundred civilians and officers establish basic inspection policies and procedures which are carried out by local offices throughout the country. A Quality Control Section is located in each of seven procurement field offices and four major plant residencies. In turn, local inspection offices have been established throughout the areas served by the field offices. The entire organization comprises roughly 1100 inspectors, as compared to a wartime peak of 15,000. The underlying policy of AF inspection is to conduct planned surveillance of the contractors' inspection and quality control systems. We buy an inspection service along with each commodity procured. Most contracts require that the contractor have an inspection system which is satisfactory to the AF representative and that only acceptable material be presented to the AF. The cost of this inspection service is, of course, borne by the Government. We have long been of the opinion that this policy promotes both economy and efficiency, since the contractor would, in any case, perform some inspection. The prerequisites of an "acceptable" inspection system are outlined in various directives and specifications which are referenced in the contract. These directives are specific enough to allow the contractor to make a reasonable bid, and are at the same time sufficiently flexible to permit the AF inspector to use his judgment as local conditions require. The legal and moral responsibility of getting quality material into the air rests with the contractor. The success of such a system is a tribute to American industry and to our economic system. Almost without exception, our contractors cherish this responsibility—they want to do a good job.

PHASE I OF AN SQC PROGRAM FOR THE AIR FORCE

Let us return now to our problem of organizing an effective SQC pro-

*Presented to the Pittsburgh Section, ASQC, October 11, 1949.

gram. It was apparent from the beginning that we would have to do battle on two fronts. It was necessary to "sell" our own people and then to induce our contractors to use SQC. Ordinarily, economy would be the best selling approach in the Air Force, but most of our top officers are pilots; you can't talk economy to a pilot where safety is concerned. So we had to point out how inadequate present inspection methods were; this, by the way, took quite a bit of pride-swallowing. Naturally, we pointed to the savings which could be realized through the reduction of scrap and rework. The prospect of conserving critical materials was a strong card in our hand. But we stressed SQC as an effective management tool for accurate, economical and objective evaluation which would provide the Air Force with better inspection protection. The Air Force is looking to the future; it does not live in the past. It did not require much selling to show that inspection is emerging from the "rule of thumb" era and is fast becoming a recognized field of applied science. I need not add that the Air Force was eager to be out in front. Suffice it to say that we made certain we had the support of our top procurement, production, and inspection officers before we did anything else.

We gave first priority to a training program. The chief of each inspection field office was put through a comprehensive 40-hour course. It is said that SQC is only 10% statistics and 90% common sense. I am afraid that we overlooked the common sense element in our first training effort. Shortly thereafter, we brought an additional handpicked group of inspectors from each field office into Headquarters for training. They had the benefits of our initial experience. Most of these men were engineers who had a wealth of inspection experience behind them. A few had studied SQC on their own initiative. During this two-week seminar (which name we found to be more appealing than "course"), we laid the real foundation for our program. We received a great deal of help from the Dayton Section of ASQC. Two of the larger manufacturing firms in Dayton invited us to visit their plants and study their SQC applications. Guest lecturers also contributed to the success of the seminar. As a result of our discussions, we were able to anticipate many problems which were certain to arise as the program gained momentum. It was here that we formulated much of our policy and laid plans for the months to come. Upon completion of the seminar at Wright-Patterson Air Force Base, our entire group proceeded to Washington and attended an advanced course presented by the Navy Bureau of Ordnance. Our first disciples now returned home, prepared to "spread the word." Their assignment was two-fold; to teach introductory courses in their own organizations and to encourage AF contractors in the use of statistical methods of quality control. The results have been truly gratifying. The cooperation of inspectors, contractors and leading quality control engineers everywhere has strengthened our faith in the Industry-Air Force Team.

Back at Wright-Patterson Air Force Base, it was apparent that the program was rapidly becoming too big for one man to handle. It was decided to civilianize the staff in order to assure continuity of effort, since military personnel are constantly subject to transfer. A young engineer was hired as an assistant and we began shopping around for an experienced man to head the program. In the meantime, there were certain policies which had to be established. We could not require contractors to adopt statistical process control, but sampling inspection could be called for in specifications and contracts. We instructed our men in the field to encourage the use of both process control and statistical sampling techniques by contractors. As an experiment, a few specifications were rewritten to include sampling inspection in lieu of the previous indefinite or unsatisfactory requirements. These specifications, of course, pertained to material which was to go direct to the AF. We had little to say about how a contractor inspected purchased parts, other than to require assurance of adequate quality. It was in this area of incoming inspection that many contractors took their first steps. Slowly, at first, they began to sample "bits and pieces", and then they progressed to more important items as they gained experience and confidence. Various sampling plans were used, but the old standby, the Dodge-Romig Tables, predominated. About this time, the AF joined the Army in adopting the former Navy Tables (Appendix X) for exclusive use on Government material. The tables became known as JAN-STD-105, and are now required for use wherever sampling is specified.

While the Air Force was thus learning the ABC's of SQC, our contractors were not standing still. In many plants, our inspectors who had never heard of SQC six months before, were facing daily bouts with Lot Plots, X-bar and R charts, and attribute sampling. There were new specifications which had to be interpreted. Many new problems arose; how would SQC affect Materials Review procedures? What effect would it have on stamping policy? To what extent could process control charts be used in lieu of final acceptance inspection? Who could establish AQL's? Many contractors were outdistancing their Government inspectors in the knowledge of SQC methods. Some of our more aggressive AF men were coming up with new ideas and techniques which needed to be evaluated. It was now time to tighten up on the reins of enthusiasm and get everyone on the same track. About this time, we effected the transfer of a highly qualified Quality Control Engineer from the Navy Bureau of Ordnance. The overall direction of the AF program was turned over to him. We might consider this as the end of Phase I of our program, which brings us up to the present time. (October, 1949.)

Before looking into the future, let us see just what has been accomplished so far. At least half of the AF inspectors have received sufficient training to enable them to maintain proper surveillance over the contractors' SQC activities. SQC has been unreservedly adopted by many of our contractors—both major and minor. Many others are still in the learning stage, with definite plans to install these methods. Some of them had been completely sold on process control when they saw the results which AF inspectors achieved by plotting control charts on certain troublesome operations. Many of them took their cues from competitors who were enjoying the benefits of SQC. Others had to get out and hustle when they suddenly found requirements for sampling inspection in their contracts. One of the major aeronautical suppliers requires certain of his vendors to furnish frequency distributions with their shipments. Others have informed their vendors that incoming material will

be sampled to a certain AQL and that they had better prepare themselves accordingly. As an experiment, we established a procedure known as "Itinerant Surveillance," for certain selected manufacturers of such standard items as anti-friction bearings. Those contractors who maintained adequate process control, and particularly those who keep satisfactory control charts, are permitted to make shipments against AF orders and sub-orders without the necessity of an AF inspector approving each shipment. Periodic surveys are made to determine that the manufacturing processes, packaging, etc., are acceptable. This plan saves the contractor a great deal of time and trouble and eliminates much of the AF itinerant inspector's travel. "Itinerant Surveillance" has been so successful that it is being extended to other industries and plants. Another forward step has been taken in the industrial fastener field. Under our "Mill Run" plan, now on a service test basis, contractors who demonstrate satisfactory process controls may have an entire production run certified by the AF inspector. It then goes into bonded stock. Thereafter, the manufacturer or his authorized distributors may make individual shipments from stock to AF Depots or prime contractors without further inspection.

PHASE II OF THE AIR FORCE SQC PROGRAM

As we enter Phase II of the Air Force SQC program, we have a staff of four quality control engineers at our Wright-Patterson Headquarters. We are establishing a similar position in each of our field offices in order to get the best qualified men on the jobs and to give official status to those who have been carrying the ball so well. In recognition of the fact that our activities extend beyond the realm of ordinary inspection, the name of our organization has been changed from "Inspection Division" to "Quality Control Division," with corresponding name changes in our field offices. This should not by any means be interpreted as an attempt to usurp any of the contractors' manufacturing prerogatives nor to relieve him of his basic responsibility for submitting only acceptable material to the AF. The change is simply being made to enable the AF to keep abreast of the best management practices.

The immediate problem facing us relates primarily to establishing standards for determining acceptability by sound sampling methods. These standards are the Classification of Defects and the Acceptable Quality Levels. Since these standards are of critical concern to Air Force contractors, it may be well to outline briefly how we propose to prepare them. A classification of defects is simply a list of all the possible defects of an item, grouped in categories of different levels of importance. Each quality characteristic, dimensional or non-dimensional, is classified in one of three main groups —Critical, Major, Minor—according to its effect on the performance of the item. Those defects that judgment and experience indicate could cause injury to personnel or cause failure of a major end product (such as an airplane) are classified as "critical." Defects which materially reduce the usefulness of an article are classified as "major"; and those defects which are more or less unimportant departures from specifications or drawings are classified as "minor." It is expected that classifications of defects for articles manufactured according to Government specifications will be prepared at Headquarters jointly by the Quality Control and Engineering Divisions. Other appropriate military services will be represented on committees which classify defects on articles covered by joint specifications. Contractors will be encouraged to prepare classifications for articles made to their own drawings. Classifications which are approved by Headquarters will be considered standard and will be applicable throughout a given industry.

An Acceptable Quality Level (in effect a statement as to the average percent of defective material we propose to accept) will be assigned to each class of defects—not to each quality characteristic. These AQL's will be determined with the advice of design, production, and quality control engineers. After the AQL is established, appropriate sampling plans from JAN-STD-105 will be used for determination of sample sizes and acceptance and rejection numbers. Provisions will be made for increasing or decreasing the severity of inspection, depending upon the performance history of the product.

FUTURE PLANS

Before closing, I should like to add a few remarks concerning our future plans. First, while the Air Force intends to take maximum advantage of process control techniques for inspection purposes, it does not intend to eliminate final acceptance inspection of completely fabricated items. However, it is planned that final acceptance inspection will be reduced to a maximum at those plants where the contractor shows effective process control. The use of control charts as an acceptance inspection device presents problems which have not been solved, but the Air Force is now formulating procedures for surveillance of contractor's process control charts. Secondly, the statistical aspects of tolerance will be thoroughly investigated; study along this line will undoubtedly lead to the establishment of more realistic tolerances. Third, the Air Force is concerned with developing improved sampling methods for destructive testing. This is an extremely difficult problem. We feel, however, that research will develop techniques which will permit more economical and accurate evaluation when destructive testing is necessary. Fourth, we hope to coordinate the work of the Materials Review Boards with Statistical Quality Control inspection procedures. Lastly, of course, we intend to continue our program of inspector training because we all realize that SQC is an essential tool which an inspector must be able to use if he is to be of service to both the Air Force and the contractor. I might add that SQC is a required subject at the Air Force Institute of Technology where our future procurement, engineering and quality control officers are being trained.

We are more than pleased with the reception our efforts have received during the past year. As a result of the cooperative efforts of industry, of the other Armed Services, and of the ASQC, our newly undertaken management methods are beginning to pay off. The saving which the Government is certain to realize through reduction in inspection and production costs will surprise no one who is familiar with the potentialities of SQC. The higher quality of materiel which we will receive will make the world's best Air Force even better.

A Talk With The Foreman About Quality Control

H. E. THOMPSON

Manager of Quality Control, Anaconda Wire & Cable Company

THE QUALITY PROBLEM

The quality problem is the old problem of producing a better product at a lower cost. It can only be done by establishing the most economical balance between the cost and the value of quality. Every one of us is concerned with this problem because it contributes to the success or failure of our company.

SIZE OF THE PROBLEM

If you were to add up the losses through scrap, the use of too much material, rework, extra inspection and customer complaints, you could determine what I call the amount of "gold in the mine". As a starter, our Accounting Department can tell us the scrap cost for the company. Add to this the cost of the other items I have mentioned and you can see that there is a lot of gold in the mine. (Figure 1.) If a careful analysis of the causes of these losses is made, the profitable seams in this gold mine can be identified. It is generally agreed by quality control engineers that after such an analysis, we will find that relatively few causes are responsible for one-half to two-thirds of all the losses, or the gold in the mine. After such a survey is made, the question is how to go about the problem of reducing these losses or reclaiming this gold.

Figure 1

WAYS TO SOLVE THE PROBLEM

To solve the problem—to strike that balance between value and cost of quality—involves all aspects of our organization. It requires training, research and experience. Some of the more important aspects are: (Figure 2.)

Quality-mindedness. It is most important that supervisors be quality-minded. In the absence of sincere interest by you, little will happen. There are large dollar gains to be made by being quality-minded. Quality does not mean building Tiffany quality into a Woolworth article. It means making the best product at the lowest cost, using the materials and standards specified for that product.

Techniques. You are the men who "make things tick". You have close contact with the workman. You know the workman's peculiarities—how he thinks and acts. You are the men on whom management must rely to put across to the man on the job our company's policies, thoughts and desires, whether they pertain to production, safety or any other subject, including quality control. You can develop quality incentives by the proper use of commendation, criticism, pats on the back, making sure your people know the reasons for defective work, and giving your men proper instruction to correct their mistakes.

Organization. This involves giving adequate recognition to the quality function. With the approval of Mr. Sprackling, a Quality Control Department was formed in the spring of 1948. It's my job to run that department. We will discuss the workings of this organization later.

Inspection Data. In order for the Quality Control Department to make a study of the process problems that you have, the obvious place to obtain information is through the Inspection Department. The greatest crime from the viewpoint of quality is to disregard the story told by inspection information, because it can be the means of preventing defects and scrap from being made in the first place, if the story the information tells is acted upon immediately.

Statistical Methods. The statistical analysis of inspection information is a new tool in our business which the Quality Control Department is u..ng, and you will hear more about it in the future, so I will tell

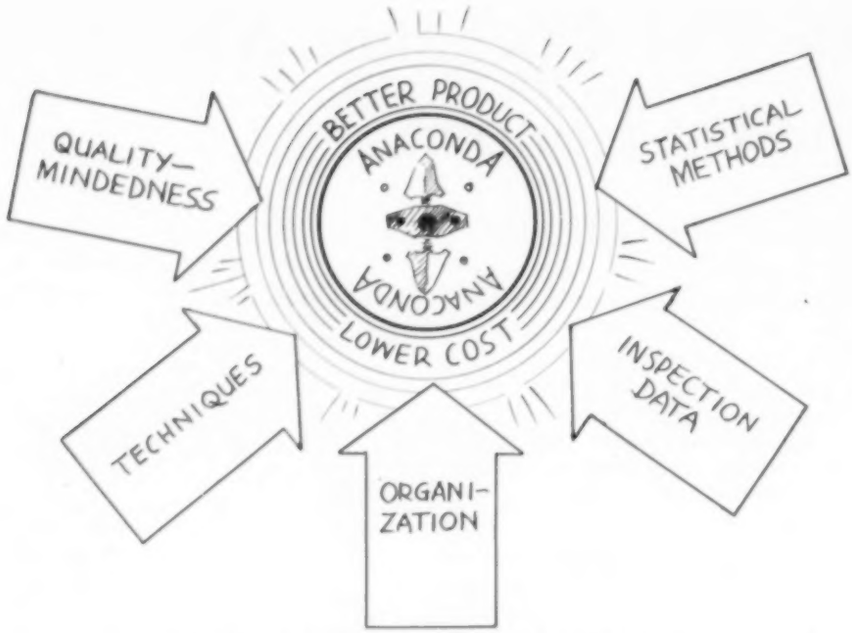

Figure 2—**Important Aspects of Quality Control**

you something about it now.

We all know that any manufacturing process has variations due to unknown natural causes. Usually these variations follow a definite pattern and are bound to happen, but we also know that when we get variations outside this normal pattern, something unnatural has happened. These unnatural happenings can be detected and corrected. If these variations are studied by statistical mathematics based on the laws of probability and then followed through, taking whatever action is indicated from the analysis, we are using "statistical" quality control methods.

THE THEORY OF PROBABILITY

I would like to give you a brief explanation of how these statistical methods are used. Before getting into this, I think it would be well for me to talk for a few minutes about the Theory of Probability. (Figure 3.)

Analogy to Insurance. If I were to ask you to name some of the soundest and strongest examples of American business, I'm sure one of you would come up with "Insurance". And I think we'd all agree on that. Certainly each of us carries one or more kinds of insurance. We have insurance policies on our lives. We have fire insurance on our homes and property. We carry automobile insurance against theft, loss, accident and liability claims. And, of course, there are dozens of other forms of insurance you can buy, covering everything from health and hospitalization to farm crops.

We all believe in insurance for the protection it provides us. It's good investment on our parts. At the same time we know the insurance companies aren't operating on a shoe-string basis. Few business enterprises have a better organized financial setup, or more money in the bank. We think of insurance as a sound, conservative business. Yet a man can walk into an insurance office one week, pay a premium of a few dollars, and the next week if he finishes in a dead heat with a fast train at the local crossing, his widow can collect 10, 15, or 50 thousand dollars. It wouldn't take too many cases like that to put a company out of business. But as you know, *that* kind of case *probably* won't happen too many times. It's possible but not probable.

And the continuing success of *all* insurance is based on the *laws of probability.* Insurance rates aren't pulled out of a hat. They are arrived at quite scientifically by statistical research. Knowing your present age, experts can tell how many more years you *probably* will live—and you pay accordingly. Your house insurance rates and automobile policy rates are based on fire and accident records in your locality. By applying the laws of *probability,* the insurance companies can calculate accurately the risk involved, and set their rates accordingly.

Laws of Probability. The *laws of probability,* then, when properly applied, make a sound foundation for operation, whether it's for insurance, in drawing to a full house in poker, playing dice, or for *quality control.* By applying the laws of probability, quality control can accomplish several important things:

First: it can make savings in manpower and materials,

Second: reduction in scrap,

Third: reduction in salvage,

Fourth: a better product with an overall reduction in costs.

I will go into these points in more detail a little later, but right now, let's see how quality control uses the laws of probability.

QUALITY CONTROL AND THE LAWS OF PROBABILITY

Just as insurance companies set up laws of probabilities on life expectancy, accident frequency, etc., so can we in industry set up laws of probability which will hold true in manufacturing results. Just as the insurance companies rely on birth and death records, studies of health programs, new building materials, and anything which affects their "insurees", so do we rely on inspection records, studies of production methods, and any factors which will affect the quality of our products. From these studies we can establish certain facts which will hold true during normal operations.

We have learned, for example, that we have to deal with two kinds of variations—*natural* variations and *unnatural* variations. When I flip a coin, I can't tell whether it will come up heads or tails on a particular toss, and as I continue to toss it, the pattern of heads and tails coming up will be rather irregular. In the long run, however, about the same number of heads will come up as tails.

Figure 3—**Probability in Action**

This is a *natural* variation.

If, on the other hand, I flipped the coin and heads came up ten times in a row, you would suspect something *unnatural* was going on, especially if you were betting on tails! You would begin to check to see that I wasn't pulling some fast sleight-of-hand or maybe using a two-headed coin. In other words, there must be some cause for this unnatural variation, and unnatural causes can be corrected. In manufacturing operations there are many factors of *natural* variation. No machine is perfect. The normal looseness in machine parts, minor variations in the size or quality of material, die wear, temperature, and similar factors cause the wire being produced to vary slightly in size from the exact dimension desired. However, wire even with this variation in size still would come within the tolerances required by the specification.

However, if we had *too much* looseness in the machine parts, a *large* variation in material size or quality, die wear or breakdown, or some other *unnatural* factor, the size of the wire would vary beyond the tolerance range. These causes which can be discovered and corrected are called *unnatural* variations.

Now, here is a curious fact: Providing the operation is affected *only* by *natural* variations, the product produced will always vary in size according to the law of probability. For the type of machine or process of interest to us, this probability curve will *always* be bell-shaped when *only* natural causes of variation are operating. (See Figure 4.)

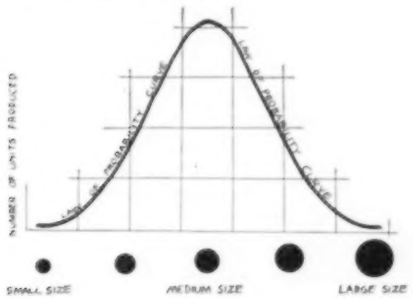

Figure 4—**Probability in Production**

So far we've been talking only about the theory behind Statistical Quality Control. To get any practical benefits, we must know how to take advantage of the probability of bell-shaped distribution curve established by normal operation, and we must know how to correct unnatural variations as soon as they occur.

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Figure 5—**Overall Diameters in Mils**

QUALITY CONTROL—EXAMPLE

I would like to show you some examples in each of the mills. However, I'll just show one problem in detail and then briefly mention work on some of the other products in the various mills.

Here's how this knowledge is being used in applying plastic insulation to wire. While a *minimum* dimension specification is required to be met, there is no *maximum* requirement. Under such conditions, it's only human nature to "put on enough to be sure". We were following the old American tradition of dishing out a baker's dozen.

At the time that this work was started, the standard practice was for the Inspection Department to inspect reels and coils of wire to the minimum requirements of the specification and either pass or reject them on these requirements. The only record that was made was the number of coils or reels that were below specification requirements, which just told management the net result of the operation.

The first step in applying Statistical Quality Control procedures was to have the inspector record the measurements, and so this chart (Figure 5) shows the recording of the outside diameters on 224 reels of one size of wire produced during

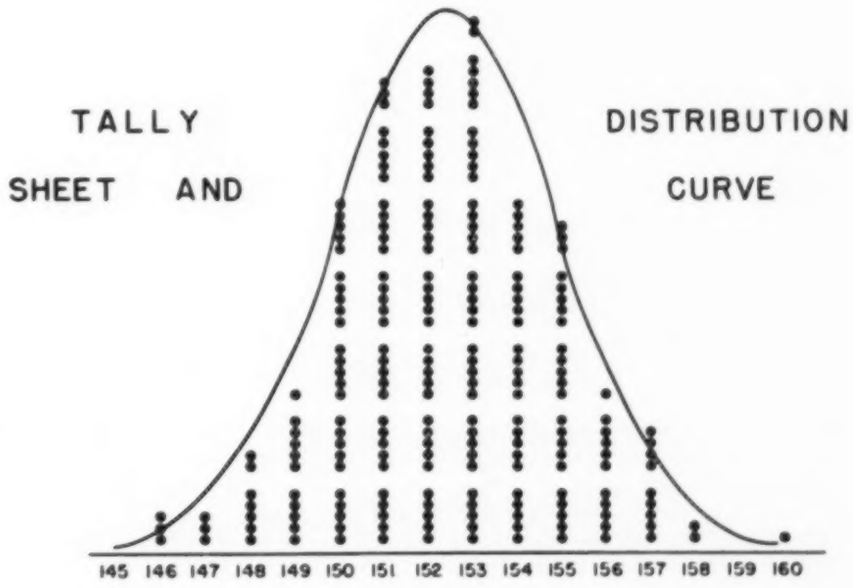


Figure 6

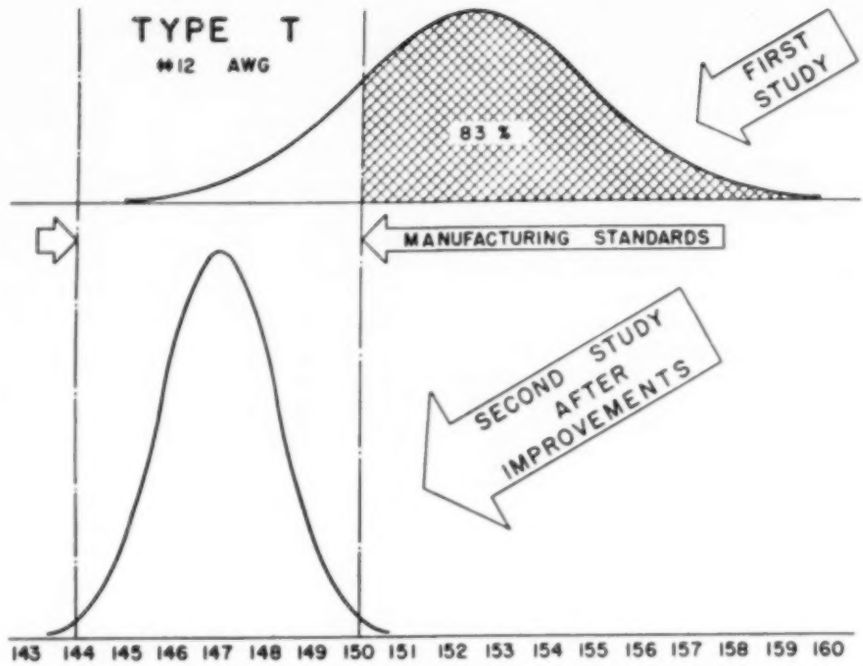
this time. From this chart you can see that there is not a great deal of information that can be gleaned because it represents nothing but a lot of figures. One can get some information from a tabulation of this kind if he checks the readings that are within the desired range. Having done this, you can see that there are a great number of unsatisfactory reels of wire.

However, if we apply a little statistical analysis to these figures by taking this information and classifying these dimensions into the different sizes, we come up with the next chart (Figure 6). This chart shows how the dimensions varied and the number of reels that had each of these dimensions. Now, superimposed on this distribution or tally sheet is the bell-shaped normal frequency curve which represents the normal probability of variation that can be expected from this process. This, then, gives you a very clear picture of the normal or natural expected variation that the machine and operators produced.

The upper curve in the next chart (Figure 7) is the same as the curve of variation that you saw in the previous chart. It also shows the vertical lines which indicate the limits that the Technical Supervisor has established as the desirable limits of variation. After the Technical Supervisor's representative had this information and studied the process, several steps were taken as follows.

The wire sent to the tuber was inspected to closer limits. Guider tip tolerances were established and new guider tips obtained. The size of the extrusion die was then changed. After all of these steps had been taken, the lower curve shows the record of production in a succeeding period. From this you can see how the amount of variation was reduced and the average diameter was shifted to a lower value. These changes in this one size of wire alone represent a considerable annual material saving. For all sizes controlled, there is a total annual saving in this department which runs well into five figures.

Of course, this saving assumes that the control shown is maintained day in and day out during the year. In order that the operators, as well as the foremen and subforemen, can see that they are staying within the limits of control, they use a control chart which is posted at the machine. This control chart is arranged in such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FIRST STUDY
MANUFACTURING STANDARDS
SECOND STUDY AFTER IMPROVEMENTS
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Figure 7—**Overall Diameters and Manufacturing Standards**

a manner that the mill checker or inspector who is checking the production from the machine can periodically place a dot on the chart to show what degree of control has been obtained by the operator during the previous three or four reels.

Figure 8 shows a simplified version of that control chart. You can see that on the left hand side there are figures indicating the variation in diameter. Each dot on this chart represents the average diameter of four consecutive reels produced and for each succeeding group of four reels, the dot is placed on the chart representing their average. From the previous information which was shown on the other charts, we have calculated the position of the upper and lower control limits shown here as dash lines. In other words, if any one dot that is placed on the chart is outside the control lines, it means that there has been loss in control, and whenever this happens, the operator should check his operating standards and try to see what has occurred and correct it. Failing this, he should notify his supervisor that something has happened that he can't correct. The supervisor should see what can be done to get back into control. It may be that he will want to get in touch with the Technical Supervisor to assist him if it appears to be something he cannot correct. A conscientious effort on the part of the operator and his immediate supervisor must be made in order that the production will remain within control.

Control charts in general are somewhat like concrete roadways that are lined on both sides by a stone wall, which represents the specification limits. The spaces between the edges of the paved road and the

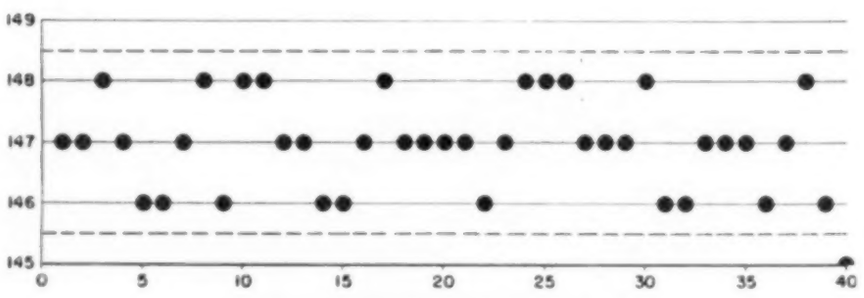

Figure 8—**The Quality Control Highway**

stone wall, known as the shoulder of the road, represent an out of control condition and the operator or supervisor should take action to get back on the pavement as soon as possible. The white line in the middle of the roadway represents the average—and that's the goal the operator must shoot for.

This improved diameter control achieved something else too. By narrowing the range in the size of this wire, we can do a better sales job. We can provide the customer with more uniform wire. We can assure him that this wire can be drawn through certain conduits, whereas under the old practice, a batch of our "generously"-insulated wire might be too large. In the past we have had complaints from customers because of oversized wire.

QUALITY CONTROL—APPLICATIONS

Statistical Quality Control techniques are being applied to some extent in all of our mills. For instance, the same techniques that were used in the dimensional control problem just illustrated have been applied to rubber insulated conductors for Building Wire with just as much success.

Results of Inspection Department tests on Weatherproof Wire are being analyzed monthly and summarized quarterly to aid management in improving control.

Considerable work is being done to analyze statistically the results of inspection of Magnet Wire in order to supply management with more accurate and detailed information for improving the control over quality. For instance, a control chart method of control was established on the solids content for plain enamel wire and it has contributed greatly to a reduction of the percentage of defective wire.

Also all of the specification tests are charted in the laboratory in such a manner that without adding any cost to the Inspection Department, the data are available to management and supervisory personnel for their day to day control of quality in production.

The results of inspection tests for tensile and elongation on all classes of bare copper wire are being analyzed statistically. In addition, special investigations have been carried on to increase our knowledge of the wire drawing process and the change in physical properties of copper wire during subsequent operations.

Effective work has also been achieved in several instances on the application of quality control methods to the testing and analyzing of raw material before being used.

QUALITY CONTROL ORGANIZATION

Before we go any further, I would like to explain how quality control is set up in the Anaconda organization. Like many of the staff operations, the headquarters is in Hastings. Here we can collect and study the information and act as a clearing house for ideas. This is simplified by the fact that the Quality Control Department and the Inspection Department come under the same head. The program at each of the mills is carried out between the Inspection and Technical Supervisory Departments working together. In general the Inspection Department is the fact-gathering member of the team and the Technical Supervisor does the process engineering that the analysis of information indicates should be done. Reports are prepared and given to local and general management covering the work that is done. It is important that you understand the differences between these two departments because often the distinction between them is confused and their operations really are quite different.

The Inspection Department must follow the specifications for our products. Its prime purpose is to O.K. or rule out those products according to how they meet those specifications. Quality Control, on the other hand, studies the information recorded by the Inspection Department and recommends changes which will enable more of our products to pass the required tests. It is generally the function of the Technical Supervisor to put these recommended changes into effect.

It's quite a bit like baseball. The Inspection Department can be compared to the umpire. He calls 'em as he sees 'em, according to the rule book. The Quality Control man is more like a coach. On a close play at third base, the umpire may call the runner safe or out. He isn't concerned with the runner's technique in reaching third base, only was he safe or was he out?

The third base coach, however, *is* concerned with the runner's technique. Maybe the runner came charging into third base standing up when he should have hit the dirt. Or maybe he used a hook slide to the right when a hook slide to the left would have enabled him to slip in safe. In other words, the coach checks the performance against the decision and then advises the runner what he did wrong and what to do the next time.

WHAT QUALITY CONTROL CAN ACCOMPLISH

How can you help in getting a good and efficient quality control program in operation? First, all department heads, foremen, subforemen, technical supervisors and inspectors must realize that each is a member of a team, that he must assume his own fair share of the responsibility and work with others to assure Anaconda high quality products at economical cost. Second, the foreman and his operators—not the Inspection Department—must be responsible for producing a quality product. Quality cannot be inspected into a product. It must be manufactured into it. No matter how many times you inspect an article, it will not be better than it is made. In departments where quality control charts have been established, it is important that the operator take action whenever a point goes out of control. He should check his process standards and you should keep an eye on these charts to see that corrective action is taken promptly when necessary. You are the men who have to make it work, and bring the Technical Supervisor into the problem whenever you feel he can help.

Here are three ways in which Quality Control can help you:

1. *Plan more economical production.* Whether we're planning our personal lives or our professional lives, we all feel better if we can set up certain long-range goals toward which we can direct our day-to-day activities. We're in a tough, competitive field. It's a survival of the fittest. Tomorrow's leaders are made today. Your job and my job tomorrow depend on how well we prepare for them today. In the early days of American industry a revolutionary development could change an entire industry almost overnight. Today, however, we have progressed to the stage where most advancements and refinements come from hard, daily plugging and the application of all the scientific "know-how" we can muster.

2. *Identify trouble during production.*
You all know the old proverb, "For want of a nail, the shoe was lost; for want of the shoe, the horse was lost, the rider was lost; for want of the rider, the battle was lost." Unless caught immediately, mistakes can pyramid into some very substantial losses. The problem, of course, is how to catch the mistakes when they first happen.
Here again an intensive study of the inspection records of your operation will tell us where mistakes usually happen. By localizing these areas, we can concentrate on setting up definite quality control checks. Once this has been done, you will have a tighter rein on your production operations.
For example, you may have had trouble because material varies in size or quality. If a control can be placed on this factor at the beginning, it is the same as making sure that no unnatural causes will be present due to this factor.
Or maybe there is a point in your machine operation where trouble often breaks out. If that can be licked, you can keep the over-all production pattern intact.
You see what actually is being done is removing the *unnatural* variations from your machines. This enables you to capitalize on the probability curve established under *natural* variations. This not only will improve production but it will speed things up when you reach the final inspection stage. Now you can profit by systematic spot-checking instead of 100% checking.
Once the proper quality controls are in effect and you are operating under normal or natural variations, the inspection problem can be greatly simplified—and at a much lower cost—by using one of the scientific sampling plans based on the same law of probability.
3. *See your problems more clearly.*
Or perhaps I should say, how you can keep out of trouble.
This doesn't imply that you don't now know how to do your job. Quality control gives you an opportunity to approach your job from a different angle. We want to give you a new perspective, pretty much the same way an aerial view of a familiar scene often brings out features which we may have overlooked or taken for granted without much thought.
The more we know about our job, the easier it is to do a better job. When you have definite signs and checks to steer by, you've eliminated more than half the cause for headaches. Quality Control is that third base coach who can signal you to keep on running or to hold up on third.
These, then, are the three ways in which Quality Control can help you:
1. Plan more economical production.
2. Identify trouble during production.
3. See your problems more clearly.

SCRAP

Earlier in this talk I mentioned one of the greatest savings that can be made through quality control—that is in connection with scrap. Last year we "misproduced" scrap to the tune of many thousands of dollars. Of course, not all of this scrap is preventable and I realize that it is impossible to run any operation like ours and as large as ours without having a fair-sized scrap pile at the end of the year. But I'm sure we can make a big dent in that figure.
Quality control methods can be used to analyze the scrap. This procedure has two desirable effects. First, by tabulating and analyzing the cause of the scrap at its origin, we can set up methods and ways to correct these causes. Second, by analyzing scrap causes on an individual operator basis, we make the operator conscious that we are paying special attention to his particular job. Naturally, he becomes more careful in his work. This is an important psychological influence.

SUMMARY

In closing, I would like to remind you that Statistical Quality Control is a scientific tool based on the laws of statistical probability; that's why it is called Statistical Quality Control. Even though all of us don't need to know the mathematical detail, it is a tool for *all* of us to use. But, like all tools, its final contribution depends upon the human resourcefulness, energy and cooperation with which we wield it.
Quality control can accomplish several important things:
First: It can make savings in manpower and materials.
Second: It can reduce scrap.
Third: It can reduce the amount of salvage work required.
Fourth: It can produce a better product with reduced costs.

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Important Advantages of Statistical Quality Control In Manufacture

A. G. DALTON

Superintendent, Quality Control, Western Electric Company

INFLUENCES AFFECTING QUALITY

The quality of all products—raw materials, parts, partial assemblies and completed products — is influenced by two general types of causes:

(a) *Chance Causes*, such as the normal and expected variations in materials, machines, manual operations, measuring devices, temperature or other atmospheric conditions, etc. These are inherent to some degree in all production operations.

(b) *Other-than-Chance Causes*, such as unexpected and abnormal variations in materials, machines, lack of skill, or carelessness in manual operations, abnormal changes in power supply, rough handling, etc. These causes can be identified and eliminated.

ADVANTAGES

1. Detection and Elimination of Other-than-Chance Causes

In order to obtain the best possible quality for the least possible cost it is necessary to eliminate the other-than-chance causes. This can be attempted on a hit-or-miss basis, or it can be accomplished by the use of statistical quality control methods. These methods applied prior to and throughout manufacture, will keep management consistently advised of the extent to which other-than-chance causes are affecting quality and these causes can then be attacked methodically and eliminated. Furthermore, unlike the hit-or-miss method, time and effort will not be spent in attempting to run down and eliminate the purely chance causes that are inherent in the production system.

2. Reduction in Inspection Costs

Inspection costs can be reduced when factors contributing to instability of product quality have been eliminated. In such cases economic sampling inspections can be used, instead of attempting to screen out defective units by inspecting each unit of product—a procedure which is far more costly and seldom entirely satisfactory.

3. Early Warnings of Unfavorable Quality Trends

Further economic advantages result from the early warnings which statistical quality control methods give of the development of any unfavorable quality trends in raw materials, in partial assemblies or in fully completed products. When promptly and vigorously acted upon, these warnings will save money that might otherwise be spent on the manufacture of products that would eventually have to be reworked or junked.

4. Detection and Elimination of Incongruities in Manufacture

The manufacturing processes and the machines or other facilities which have been provided may be perfectly good, but they may also be incapable of consistently producing the level of quality desired. Requirements may have been established which appeared to be eminently desirable, but which cannot be met consistently and economically with existing plant facilities. Attempts to meet desired quality levels under such conditions are usually a waste of time and money. Statistical quality control will aid in identifying these conditions, and in such cases money spent in redesigning the product or the facilities, or in changing the processes, can be counted on to pay dividends in reduced scrap, reduced inspection costs, reduced unit costs, and more uniform and better quality.

5. Aid in Economic Design

Statistical quality control procedures provide a cumulative store of knowledge with respect to material and process capabilities which is extremely useful in the design of similar products, since it permits the designer to make the most economical use of raw materials, machines and procedures, the individual and combined behavior of which can be predicted within limits from previous experience.

6. Improved Producer-Customer Relations

There are also less clearly defined economic advantages, in improved producer-customer relations. For example: knowledge that a manufacturer is employing sound statistical quality control theory and practices throughout manufacture, and is willing to furnish his customers with inspection results, should have a definite sales value to customers who, on the basis of this evidence, feel they can reduce or eliminate their own acceptance inspections of product furnished from such manufacturers. Also, statistical quality control, properly applied throughout manufacture, results in more uniform quality at lower cost and at the same time provides more reliable and more useful inspection results than any 100% inspection involving judgment or the possibility of human error, or even a series of such 100% inspections. A manufacturer who relies entirely on detailed inspections of each unit of product to protect his quality cannot compete successfully, either in respect to uniformity of product quality or in production costs, with the manufacturer who makes full use of statistical quality control practices.

Quality Control at The Weatherhead Company

J. FREDERICK VERIGAN

Director of Quality Control, The Weatherhead Company

BACKGROUND

It would be pertinent to give a little background material on the Weatherhead Company. This company is one of the world's largest manufacturers of screw machine parts for all types of customers. The products made by this company are used by most automotive concerns, many refrigeration manufacturers, aircraft companies, etc. The number of different items manufactured seems almost innumerable. Some of these parts are assembled in our own plant and marketed as assemblies. Some of the products are valves, receiver tanks, dryers, etc., for the refrigerator trade; valves, regulators, tanks, etc., for the liquid petroleum gas industry. Essentially, however, it is a very large job shop, specializing in high-speed screw machine production.

The factory manager, Mr. E. A. Newgren, had attended one of the War Production Board Courses at Purdue University. He had tried the quality control technique on several troublesome jobs and had been satisfied with the results. For several years this was the extent of the quality control work. In April, 1948, it was decided to install a quality control program, which was to be more inclusive than the earlier trials. The writer was appointed to direct the program.

The quality control department was set up to report directly to the factory manager. Since we already have an inspection department, it might seem that this is a parallel organization. This is true to a certain extent, but is has worked out successfully. The quality control department confines its activities to analyzing the manufacturing process and controlling the quality on the specific lines of work assigned to it. Where the checking of quality at these machines had been previously done by a floor inspector, he was relieved of these machines and given more time to perform okey or first piece inspection. Thus, the activities of the quality control department are confined at present to a few departments, while the present inspection department carries on its normal activities over the entire plant.

TRAINING PROGRAM

At first, six female employees were carefully selected to become the first group of quality control operators. These people had all had previous inspection experience and were high school graduates with an ability to handle mathematics. They were selected for their ability to get along well with each other and other employees. After this careful screening, they were given a very extensive training course in quality control techniques. It was decided to have the training classes in session each afternoon only, allowing the employees to pursue their regular work in the morning. It was felt that the subject matter would be more firmly fixed in their minds if it was not poured in all at once.

The training course itself covered 22 sessions of 3 hours each. The first session was a general introduction to the field of quality control and a discussion of the terms and symbols used in this field. The second class was on basic statistical methods, demonstrating the computation of the average, range, standard deviation, and a demonstration of basic frequency distribution anaylsis. The next 11 classes were spent on the control chart for variables. In these lessons we introduced the normal curve, and demonstrated the relation between the distribution of individual observations and averages of these observations. The decisions preparatory to setting up a chart were discussed. Then followed many hours of actual construction of control charts using data obtained from the bowl of beads. After at least three sets of data had been drawn and charted, several sessions were devoted to the preliminary analysis of these data. In these lessons, we practiced setting control limits, emphasizing the need to check the location of $\bar{\bar{X}}$ with reference to the specification tolerances and checking the natural tolerance (6σ) against the specification tolerance. In our opinion, this is the most important step and must be thoroughly mastered. We then went to setting of standard values, stressing the economic factors involved. To demonstrate different typical situations, data from the writer's past experience were introduced and studied. At the end of these eleven classes, a review was given to check the student's progress. At this point a session was devoted to practice on the use of gaging instruments including air gaging, surface analyser, tool maker's microscope, thread comparators, and optical comparators. The next three sessions were devoted to the fraction defective chart. The basic theory was explained and demonstrated, again using the beads. Each student spent a lot of time drawing samples and constructing charts, altering the fraction defective to show the relative insensitiveness of this technique. Sample sizes were altered to demonstrate the increase in effectiveness with an increase in sample size.

We next devoted a few classes to sampling inspection. The instruction was confined to a discussion and demonstration of how to use the published tables, Dodge-Romig, Army, and Navy. Instruction was given in the basic underlying theory behind these tables. The producer's and consumer's risk were discussed; practice was provided in constructing an operating characteristic curve and an AOQ curve, showing the AOQL concept. Admittedly, we could not do justice to sampling inspection in so few lessons, but since these people would have very little occasion to use it we only wanted to introduce them to the subject. Later a course on sampling inspection will be held

for those persons whose responsibility will be the operating of sampling inspection plans.

At the end of this course a very detailed test was given, designed to test the student's ability to bring the theory to bear on practical problems. It was necessary for the student to pass this examination with a grade of 70 to be eligible for assignment to the quality control department.

The number of people instructed at one time was purposely kept very small, so that individual attention could be given. Each succeeding group numbered six or seven employees. In each class we also instructed some inspection foremen; we hope, in future classes, to include several employees of the Tool Design and Engineering Departments.

All production foremen were given a series of lectures in quality control in which the control chart for variables was thoroughly demonstrated. At the conclusion of this series of lessons, Mr. Collier showed us his movie "Modern Quality Control". This made a great impression on all who saw it.

PUTTING SQC TO WORK

It was decided that the quality control department would confine its work to the refrigerator valve products and to products used by the liquid petroleum gas division. The newly-trained employees were assigned to two automatic screw machine departments doing largely first operations and one department concerned with secondary operations. In each of these departments, a quality control station was established with air gages, thread comparator, etc., for the use of the quality control department.

It is well recognized that a job shop is one of the most difficult types of operation to cover with quality control. This fact is made more difficult perhaps when the plant is a very large one, and where the operations are predominantly high-speed. We have encountered most of them; the difficulty of maintaining any "lotting" of work, in order to segregate bad lots; the problem of maintaining a steady, even amount of work for quality control personnel, etc. Perhaps one of our most persistent problems, as with any job shop, was the problem of getting enough subgroups upon which to establish limits before the job ran out. These are only some of the problems not faced by quality control applications in a manufacturing process that makes the same product day after day. Some of these problems we have solved; others we have not solved yet, but we are confident that given a little time they will be solved.

In the quality control office a central file is maintained by part numbers. This is kept on a specially printed 3 x 5 card. Each day this office receives copies of the inspection report showing reasons for rejections on various parts; the salvage report, showing the parts that have had to be reworked and for what reason, the returned material report showing defects in any returned material, copies of customer complaints and data on the sampling inspection done by final inspection. These are our source records for the dimensions to be checked on the parts which quality control is covering. A 3 x 5 file card "Notice to Quality Control Operator" is made up to show the part number, shop order number, and dimensions to be held on quality control. A note "Return to Quality Control Office at completion of order" completes the layout of the card. The dimensions which we desire to control, based on the above source records, are listed on this card. The quality control group receives a report of all jobs set up daily in the three departments we are working in. When this report shows that one of the parts that quality control is covering is set up, the file card for that part is sent from the Quality Control Office to the quality control operator. The receipt of this card notifies the quality control operator which parts are assigned to her and which dimensions on these parts are to be controlled. With this pertinent information, the quality control operator is able to prepare the charts and begin to collect subgroup data.

The sample size for $\bar{X}$ and R charts varies somewhat with the type of machine under observation. In one department for instance, most of the machines are six spindle automatic screw machines. Changes in the quality characteristics under observation can be caused by two different sources: (1) the tooling set up, and (2) a defective spindle. In the case of a quality characteristic being affected by the tooling set up, each of the six pieces will be acted on by the tooling set up and will quickly produce an average out of the control limits. In the case of the quality characteristic being affected by the spindle adjustment, it is possible to have only one piece out of six affected. In this case, it is usually not affected sufficiently to throw an average out of the control limits. Yet we are very desirous of detecting not only a change in average caused by tooling but also a change in quality caused by a loose or defective spindle. We, therefore, use a sample size of six pieces. This sample consists of six consecutive pieces from the machine. Therefore, each spindle is represented in each sample, although usually no attempt is made to preserve the spindle identification in this sample.* If the average of the sample is within the control limits, the machine is allowed to run; if it falls beyond the control limits, the machine is shut down for adjustment. In addition to this action, the quality control operator watches the range for each sub-group. If the range appears suspiciously high, the subgroup is checked to see if this high range value is caused by one extreme value. This condition usually indicates trouble caused by a spindle. If the data show one extreme value, a second subgroup is immediately taken being careful to preserve spindle identification. If the same condition repeats itself, we shut the machine down and make the necessary spindle adjustment indicated as causing the trouble.

In our other automatic departments, the machinery is largely single spindle (Brown & Sharpe). We use a sample size of five in these departments. Also in this department, we use fraction defective charts on many of the jobs. Since the bulk of our trouble is with threads, we are forced to use the orthodox type of go not-go gages. In the keeping of fraction defective charts we use a sample size of 25. We realize that a sample size of 25 is too small to show slight changes in fraction defective. In this case p will change only in increments of 4%. This sample size was the result of a practical operating decision forced by the need of lessening the inspection load at each machine in order to extend the coverage of quality control. Even this small sample does permit us to discover serious variations in the quality of parts. We find that fraction defective work is not as satisfactory

*We recognize that this procedure of sampling "across the machine" gives us stratified samples which could lead to inflation of $\bar{R}$ because of assignable causes of differences in level or variability between spindles. However, we have found the use of a single chart, based on standard values for $\bar{X}'$ and $\bar{R}'$ (and using these stratified samples) to be sufficiently sensitive in our case for effective control purposes.

as variables inspection. However, we are presently forced to resort to this, particularly on threads, not being fully equipped with thread gages giving us a direct reading. We are in process of replacing the go not-go gages with the direct reading type gage and therefore, substituting as quickly as possible $\overline{X}$ and R charting on threads for the present fraction defective method. This, of course, will take time.

Again, we are plagued by short run jobs. In order to take care of this, we have developed the use of the frequency distribution analysis. In this analysis, the operator waits until the machine is approved by the inspector. She then takes the first fifty pieces and measures the quality characteristics involved. These results are tallied and the $\overline{X}$ and standard deviation calculated. The tally is a rough picture of the distribution and the $\overline{X}$ and standard deviation help us to decide whether or not the process is satisfactory. The same procedure, a sample of fifty, is repeated at the end of the run, and again the distribution checked against the tolerance. We have designed a tabulation form which makes the calculation quite simple.

At present, our quality control inspectors handle four machines each, checking each machine at a maximum interval of one hour. All machines have a minimum of two dimensions being checked. A steady average is nine dimensions per quality control operator. This means that each girl measures about 54 dimensions per hour, or about one per minute. In many cases we have increased this and feel that it will increase in the future. The operators checking fraction defective also handle four machines.

At the completion of any shop order, the data sheets, charts, and the 3 x 5 notification card are returned to the quality control office. The $\overline{X}$ and $\overline{R}$ are recalculated and the control limits revised accordingly. At this time, the charts are also carefully examined for data especially interesting to the tool design and engineering departments. This information is then forwarded to them. The charts which demonstrate poor operator influence or situations that are under the jurisdiction of the manufacturing department are discussed with the plant superintendent and methods of correction decided upon. The data sheets and the 3 x 5 notification card are filed in the quality control office. The charts with the *latest revised limits* are returned to the quality control operators. These are filed in the operating department. Hence, the next time the quality control operator receives a notification card to control a certain job, she merely removes the chart from the file and is ready to proceed.

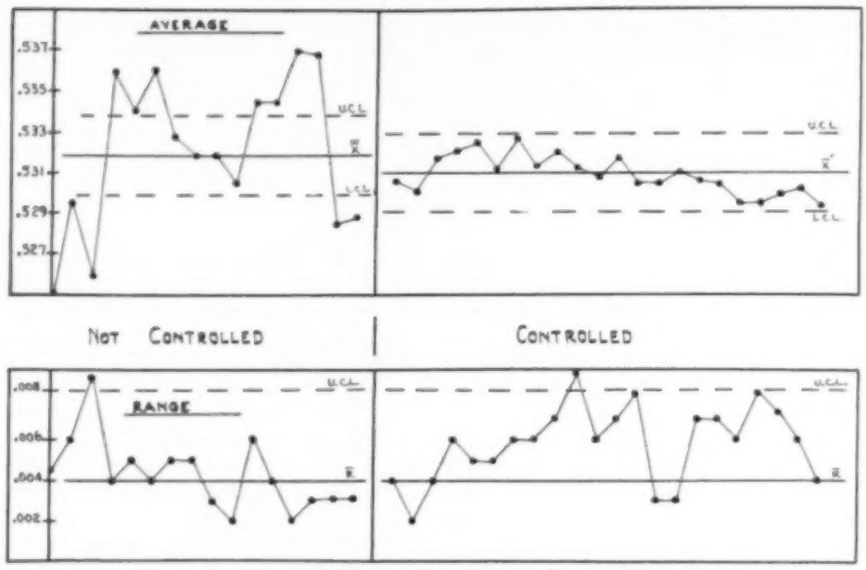

Chart 1—**Control Charts For Dimension In Figure 1**

The same procedure is followed with the fraction defective chart, except that we may arbitrarily adjust the p′ and limits before returning the chart for filing.

CASE HISTORIES

We have experienced the typical results of a quality control program. These are illustrated in the following three examples.

Illustration No. 1. Figure 1 shows the part being manufactured. The dimension being checked is the depth of the hole, given as .531″ ± .010″. Perhaps this seems like a very large tolerance, one too large to need the help of a control chart to keep the parts within limits. A glance at the chart will show otherwise. Actually, we had experienced considerable trouble due to this dimension. This part was made on a six spindle automatic machine.

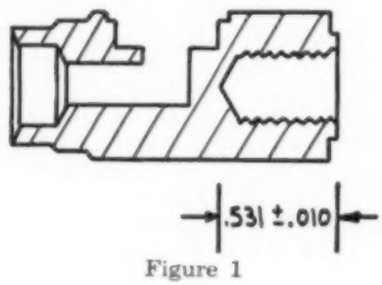

Figure 1

Chart No. 1 shows the situation before and after control. The average depth of hole, prior to quality control is very erratic, with an $\overline{X}$ of .5319″. The variation as measured by $\overline{R}$ is .0040″. The value of sigma estimated from this $\overline{R}$ is .0016″. This shows that the tolerance can be met easily, as six sigma is equal to .0096″.

The $\overline{X}'$ was therefore, set at the drawing mean (.531″) and control limits set from the preliminary data. The operator was shown the chart as each succeeding point was plotted and succeeded in holding the averages within the control limits. This is shown in the portion of the chart marked "After Control".

The second portion of the chart shows an increase in the range while still within the control limits, with the exception of one point. A recalculation of the data shows the $\overline{R}$ for all subgroups to be .0052″. This gives an estimated sigma of .00206″; therefore, the machine can still meet the tolerance. Naturally, the control limits were increased to agree with this new $\overline{R}$ on the next shop order.

Illustration No. 2. Figure 2 shows the part being manufactured. It is an insert for a refrigerator valve. The dimension .4075″/.4090″, shown in Figure 2, is a press fit dimension. It was, therefore, important that the $\overline{X}'$ be held somewhere near the maximum dimension. It was decided by management to set the $\overline{X}'$ at .4085″ and was further decided that points out of control above the upper control limit would not be as serious, in this case, as points out of control below the lower control limit.

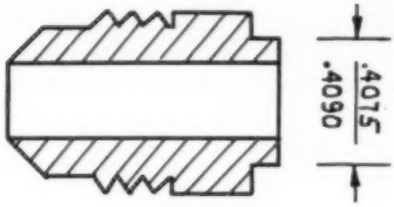

Figure 2

The first production order was made on a six spindle automatic screw machine. The section of Chart No. 2 labeled "Machine A" shows the result of this run. The $\bar{R}$ for the eighteen subgroups was .0008". The standard deviation estimated from this value is .00031". Since the drawing tolerance was .0015" and six standard deviations were .00186", the situation was unsatisfactory. The level of work determined by the $\bar{X}$ was higher than the $\bar{X}'$, with lack of control shown.

On the next production order, the same part was tried on a six spindle automatic screw machine of another type, labeled "Machine B" on Chart No. 2. The $\bar{R}$ for this series of subgroups is .0004". The estimated standard deviation from this $\bar{R}$ is .00016". These data reveal that with this type machine the drawing tolerance can be met (six standard deviations = .00096" against the drawing tolerance of .0015") if control is maintained.

The control limits for averages established by the new $\bar{R}$ show the limits between which averages from this process should lie. They are only ± .0002" from the $\bar{X}'$. There are many points out of control even though the averages group themselves more closely to the desired $\bar{X}'$ than in the previous run. Remember that we are interested in making a decision between two machines. We are interested therefore, in the range chart. If the range chart shows considerable improvement, the operator could learn to hold the $\bar{X}'$ in better control. The $\bar{R}$ on "Machine B" is much better.

A further check will help to clarify the points out of control on the $\bar{X}$ chart. The extreme acceptable limits

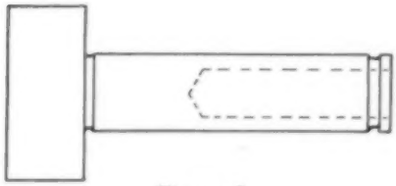

Figure 3

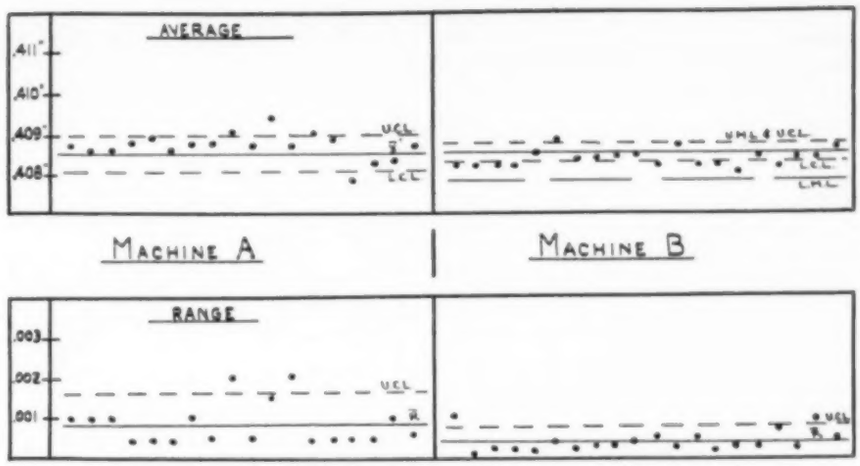

Chart 2—**Control Charts For Dimension In Figure 2**

for averages in relation to the tolerance are the "modified" limits. If "modified" limits are constructed from the specification limits, the upper limit will coincide with the upper control limit (.4087") and the lower modified limit will be as shown in Chart No. 2 (.4078").* It is seen that all except one point were within these modified limits.

With this information this part was always scheduled to be run on "Machine B". There was a pronounced drop in the number of rejects for poor press fits. Incidentally, subsequent charts show excellent control on the $\bar{X}$ chart, due no doubt, to the operator's increased experience in the use of the control chart for machine adjustment.

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*UML = USL − ($3\sigma' - A_2\bar{R}$)
= .40900" − (.00048" − .00020")
= .40872" = UCL
LML = LSL + ($3\sigma' - A_2\bar{R}$)
= .4075" + (.00048" − .00020")
= 407888"

Illustration No. 3. This illustration shows the use of the control chart in determining the effect of changing tooling setup.

Figure 3 shows the part being manufactured. The quality characteristic under consideration is the concentricity of the hole with the O.D. The drawing tolerance allows a maximum .002" total indicator reading. The part is made on a six spindle automatic screw machine.

This characteristic is very important and has been the cause of many customer complaints. With the tooling setup normally used, shown as "Tooling Setup No. 1" on Chart No. 3, the picture is not too good. The $\bar{X}$ chart is erratic and so is the range chart. The $\bar{R}$ for the series of subgroups is .0013". The estimated sigma is .0005". Thus, the tolerance of .002" cannot be met satisfactorily with this process, even if in control.

An entirely different type of tooling setup was made. The next series of subgroups labeled "Tooling Setup No. 2" shows the process with this

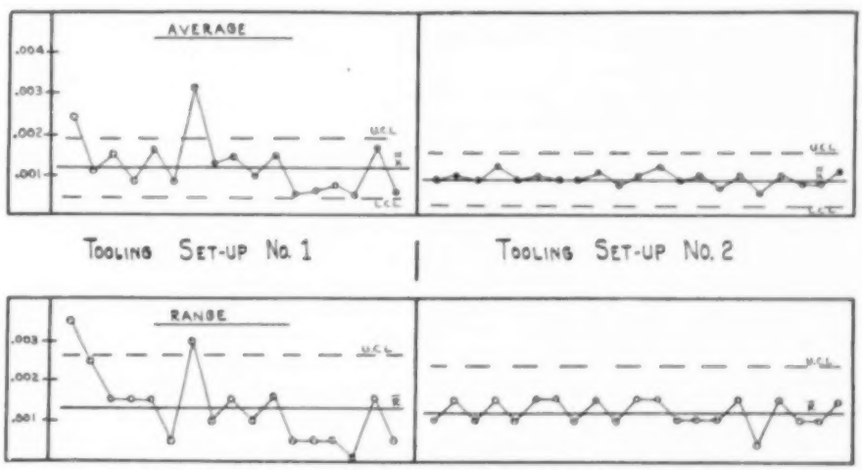


Chart 3—**Control Charts For Dimension In Figure 3**

tooling. The $\overline{X}$ had been reduced to .0009". The $\overline{R}$ is nearly as bad as before, but range variation is much more uniform. The $\overline{X}$ chart also shows much more uniformity with no points out of control. The process will still not meet the specification, but the percentage of parts outside tolerance has been reduced.

Using these data as a basis, "Tooling Setup No. 2" was established as a standard for manufacturing and has successfully reduced the number of rejections caused by this characteristic.

SUMMARY

In conclusion, we experienced the following results from our quality control program in the short space of six months.

1. Reduction of scrap on the refrigerator valve line.
2. Better basis for machine scheduling of parts.
3. Definite methods of determining which tooling setups are best.
4. General improvement of quality due to use of control charts.

We realize that we have just scratched the surface. We plan to expand slowly, consolidating our gains as we progress. We are confident, based upon the results of our program so far, that quality control can be of great benefit to our company.

SO THEY SAY . . . .

Comments in letters from advertisers and contributors

"We believe very much in quality control and have spent a lot of time and effort on it, so that the work that you are doing is certainly interesting to us."

. . . . Electrical

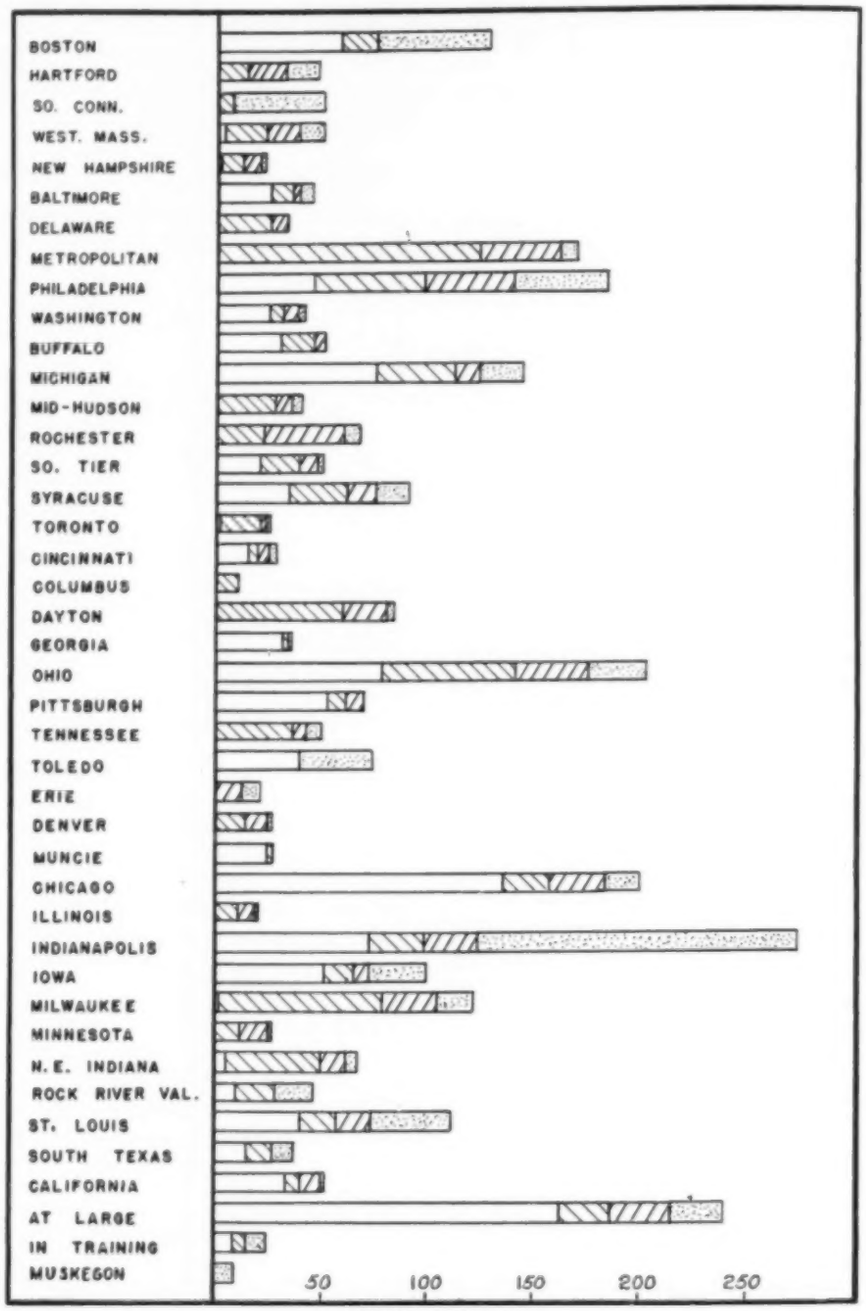
"Some years ago we realized the value of this statistical approach for quality control. We therefore set up a program for a Quality Control Department . . . . in order to take advantage of these newer techniques. We felt that this program would result in additional mutual benefits to our customers as well as ourselves, and from our experiences we know that this has been the case."

. . . . Fabricating

"We are highly in favor of advancing this method of improvement in the quality of manufactured products."

. . . . Automotive Equipment

BAR-CHART OF PAID-UP ASQC MEMBERS PER SECTION AS OF MARCH 28, 1950



The chart shows considerable progress during the past year by each Section of the Society. The dotted portion of each bar represents the increase in membership between Jan 23 and March 28, 1950.

Congratulations are due the Indianapolis Section for an outstanding job in more than doubling its membership during the past two months. Philadelphia, also, has more than doubled its 1948-1949 membership.

Three Sections, Indianapolis, Ohio, and Chicago already have passed the 200 member mark and several others are close behind including Philadelphia, Boston, Michigan, Milwaukee, St. Louis, and Iowa.

Total membership of the Society now exceeds 3200, or better than 21 percent above the total 1948-1949 figure. At the current rate ASQC will have a membership of about 3,800 by June 30th as compared with the original goal of 3.500 set at the beginning of the current membership year.

J. R. STEEN, *Chairman,* Committee on Membership

Statistical Quality Control And Its Position in the Naval Ordnance Shore Establishment

EDITORIAL COMMENT

This article is an editorial summary of some material appearing in a recent Naval Ordnance publication. The intent of this comment is to show some of the aspects of Quality Control, its advantages as viewed by the Navy, and the position it occupies in the production activities under the management control of the Bureau of Ordnance.

—Mason E. Wescott.

The primary tools of Statistical Quality Control as used by the Naval Shore activities are described below:

(a) *A Classification of Defects* is a check-off list of all drawings and specifications requirements that can be inspected without destruction of the item. Defects are divided into four categories of importance, briefly:
  (1) Critical (safety)
  (2) Major (failure to function)
  (3) Minor A (minor operating deficiency)
  (4) Minor B (good workmanship—non-functional)

  (Critical, Major, Minor A and Minor B defects are further defined in the Joint Army-Navy Standard No. 105.)

(b) *Acceptance Sampling Tables:* Joint Army-Navy Standard No. 105 is a set of tables to inform the Navy Inspector what sample size he should use on the basis of the AQL required for each class of defects for a given quantity of material to be evaluated.

(c) *The Process Control Chart* is used to plot data obtained from successive small samples and calculated to give a maximum amount of information and to indicate whether all the material produced since the last check is within drawing or specification requirements.

Naval Ordnance shore establishments manufacturing materials for the Navy are responsible to the Bureau of Ordnance for the quality and quantity of material produced. At most activities there is an individual assigned the responsibility for quality (Inspection Officer) and there is one assigned for quantity (Production Officer).

Comparable to the private contractor producing material on contract for the Navy, the production function of the shore establishment is to produce the material in accordance with the drawings and specifications. The Classification of Defects will tell the contractor or the Navy Production Supervisor the importance of each characteristic.

After the material has been submitted in accordance with the drawings and specifications, it is inspected by the Navy Inspector. After selecting a random sample from the lot of material (based on the tables in JAN-STD-105 and by utilizing the Classification of Defects), he either
  (a) accepts the lot of material for further assembly, shipment, or storage, or
  (b) rejects the lot of material and returns it to the producer for screening, depending on the number of defects found.

The Process Control Chart indicates that the material being produced is either within the tolerance limits (Acceptable) or outside the tolerance limits (Not Acceptable). This information is of great importance to the Production Supervisor since it tells him when
  (a) to employ screening inspection for removal of defectives;
  (b) to reset the machine to prevent the manufacture of defectives;
  (c) to resharpen or retool the machine to prevent production of defectives, or
  (d) to leave the machine alone.

In addition to the above, the control chart will indicate what tolerance each machine is capable of holding and will aid the Production Supervisor in selecting the proper machine for the job. The control chart will indicate the trend toward producing defective material which can be observed and corrected, thus reducing the scrap rate. The Navy Inspector, on the basis of control chart information, may employ reduced Final Acceptance Inspection with a resultant reduction in overall cost.

The increasing use of quality control techniques by contractors engaged in supplying ordnance materials is expected to greatly increase benefits through reduced cost to the government. The benefits would be especially important in case war emergency required rapid procurement of very large quantities of materials. The contract specifications provided to the manufacturer would include the classification of defects for each item. This classification of defects would provide the contractor with the specific information required to coordinate closely the quality of his product with the sampling plans used by the Navy Inspector.

An exhibit by the Navy at the ASQC Convention in Milwaukee, June 1-2, will illustrate the application of the primary tools of statistical quality control as used by naval activities.

Quality Level Certification*

LEO HARRINGTON

Chief Inspector, King-Seeley Corporation, Ann Arbor, Michigan

INTRODUCTION

Quality Control Engineers are constantly searching for better methods of controlling quality at less cost. New control techniques are being developed and published in books and industrial magazines. These techniques cover control charts, sampling schemes, analysis of test data, and the administration of control.

It will be the purpose of this discussion to concern itself with one of the newer developments in the field of Quality Control, often referred to as "Quality Level Certification."

It seems almost essential to begin this discussion with a few simple definitions if we are to avoid confusion and misunderstanding.

When we speak of "quality" we shall mean a characteristic's compliance to manufacturing standard. The term "level" will refer to the specified allowed percent of non-complying articles to be found, on the average, in a series of lots submitted for test. By "certification" we shall mean written declaration by responsible authority that the "Quality Level" has not been exceeded, as exhibited by the required data and test procedures.

Some companies have recently started a movement to have "Quality Level Certification" included in the purchase contract. In a few simple words this means that the supplier is requested to furnish, with each shipment of material, recorded and authentically indorsed, statistical evidence that the quality of his material meets contract requirements.

What do these companies hope to gain by such a movement? Those who have promoted the idea claim Receiving Inspection can be practically eliminated. Besides this reduced inspection cost, they further claim that scrap, labor, and material losses will be reduced. Finished product quality will be improved. It is their contention that most receiving inspections are costly and inefficient. They maintain that defective material rejected at the receiving room door impairs good vendor and customer relationship. It brings unwarranted additional expense which eventually becomes a part of the production cost. It is felt that quality level certification will make the vendor responsible for supplying good quality material and will force the buyer to make more evident to the vendor what quality he is demanding. We must admit that such results are ideal and well worth pursuing.

Industrial reaction to all of this is worthy of note. Some companies declare the idea unworkable and impractical; they want no part of any such program. Some believe the idea has merit but choose to wait while others experiment and develop methods and procedures. Some manufacturers have become intensely interested in the movement and have decided to pioneer. The result of this pioneering will dictate their ultimate position.

In the fall of 1948 our company was asked to enter a Quality Level Certification program. After detailed investigation a program was adopted which satisfied the request of our customer. We were not convinced the program was as effective as it could be and so we decided to continue investigating possible refinements. This research revealed many factors which we are convinced are important to any consideration of a Quality Level Certification program. Let us now discuss these factors.

SPECIFICATIONS

Specifications, the industrial laws for the regulation of quality, will be our first concern.

Specifications must take into consideration what can be produced and what is actually required. Superfluous requirements must be weeded out. The ambiguous and incomplete specification must be revised. Also, specifications must be graded according to their importance in the control of quality.

Your purchasing agent has been charged with the responsibility of interpreting your company's needs and passing them on to the supplier. With poor and incomplete specifications he has been forced to gamble and guess in his attempts to save his company money. Considering the handicap, most of the time he does an exceedingly fine job of procurement.

Vendors in their attempts to interpret specifications, and visualize customer needs, many times have placed the quality emphasis on the minor characteristics and neglected major ones. Consequently, parts have been made incorrectly, resulting in costly rework and scrap. Customer and vendor relationships were thereby strained and this ultimately reflected itself in the price.

Because of its inability to evaluate and interpret specifications correctly, your Inspection Department often makes unnecessary and unwarranted rejections of purchased materials. Once again, customer and vendor relationships are placed under tension. Your Purchasing Department is embarrassed and burdened with needless extra work.

By grading specifications into critical, semi-critical and non-critical categories you will reduce your specification problems to a minimum.

The critical group should include all characteristics which require complete adherence. Failure to produce to this type of specification will result in scrap, expensive rework and functional failure of the article being manufactured. This group should warrant intensive and efficient gauging to maintain control. It is on these characteristics that we wish to place the emphasis of control.

The semi-critical group should include characteristics which must be held to specification most of the time

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but which are not subject to abnormal variation once the tooling has been proven. Scrap and rework will not be costly if these characteristics fluctuate slightly out of bounds. Periodic inspection will furnish ample control.

The non-critical classification contains all characteristics not assigned to the critical or semi-critical groups. Failure to meet such specification will not result in scrap, rework or product failure. The main function of this type of specification is to give the part shape and to regulate tooling.

The grading of specifications for control purposes is not new. Informally we have been following such practice for some time. We have all noticed the inspector selecting certain characteristics to be checked and neglecting others. Such selection has been a matter of judgment and experience seasoned with intuition, personal prejudice and over-ambition. Its effectiveness is greatly reduced by frequent losses of memory, forgetfulness, labor turn-over and the fact that some people never seem to evaluate things adequately.

INSPECTION MEASUREMENT

Next we shall consider the problem of inspection measurement to determine quality.

We determine the quality of the manufactured product by inspecting it. The accuracy of our determinations will be dependent on the effectiveness of our inspection. Before the customer and supplier can agree that the required quality has been provided they first of all must agree on the method to be used to determine the quality. The same characteristics must be considered by both parties and the measuring instruments must be agreed upon. For example, the vendor who uses a micrometer to check a turned diameter may claim that he has produced his product to specification. The customer, by employing a ring gauge, may prove the product in error.

You can easily avoid this trouble if you list all specifications on a form sheet. Each specification will be shown as graded and grouped in its proper classification. Associated with the specification will be the measuring method to be used by Inspection in testing the article. As to what characteristics shall be included in the quality determination, it is customary to use only the critical items. Record of this requirement can also be made on the form sheet. Both the customer and vendor will have a copy of this form and both will be fully advised.

QUALITY LEVEL

Having settled the problems of what is to be checked and how it is to be checked, we now must reach an agreement with our supplier on the quality level. This is not an easy task. Each party must be sincere and willing to compromise when independently selected levels of quality differ.

The customer must take into consideration the cost of rework and scrap when establishing the quality level. He must determine the effects the various levels will have on his finished product's quality.

The vendor must be aware of what quality level his production process can reasonably hold. If he doesn't know he must find out, for quality level negotiations must be spared from false sales promises that can't be fulfilled.

Your selling price cannot be justified when challenged by a competitor's price unless the true level of your quality is known.

Past inspection history usually is of little value in determining quality levels. Lack of uniformity in specification coverage makes the record biased and unreliable. Variations in test methods are a contributing factor. The company that uses quality control methods in Receiving Inspection without standardizing the inspection procedures will also find but little value in past history as an aid to quality level determination.

By means of cooperative effort between vendor and customer Quality Control Engineers a quality level satisfactory to both parties can be established. Quite often committing yourself to this level results in the improvement of your product's quality to a level previously believed to be unattainable. Your desire for quality insurance forces needed design changes, improved processing methods, and better tooling. Your quality not only improves, but production cost is lowered when rejections fall off and inspection labor is reduced. These facts are brought out because there seems to be a reluctance on the part of manufacturers to commit their products to any specific quality level. The tendency to avoid a "fenced in" position regarding quality may be costing money and additional business.

CERTIFICATION

We are now ready to consider problems pertaining to certification. The statistical evidence that quality requirements have been met will include control charts and records of statistical sampling. The supplier will be asked to furnish this evidence with each lot shipped.

Producers of small machine parts will have no difficulties in performing this test. However, those who produce assemblies on fast moving assembling lines may have problems when test procedures are slow and cannot be synchronized with the speed of the line. Sampling may have to be performed while the goods are in storage waiting shipment. This may require an increase in storage space so that lots may be kept separate while the sampling inspection is being performed. The time usually allowed for making up the order for shipment may have to be increased. Inventories of finished goods may have to be expanded. When finished assemblies are expensive and the past policy has been to work with minimum inventories, companies will not increase their capital in use without good reason. Still others may not be in a position to do so.

The customer must realize that if he puts the vendor to extra work he will have to pay the bill. When he can cut his own production costs by guaranteed quality he can afford to pay more, so long as the increase in price does not exceed the production savings.

The certification record should be endorsed by the supplier's Quality Control Manager or a responsible member of his department. The customer will then be assured that the data have been adequately reviewed before the material was shipped.

GENERAL COMMENTS

After the program of quality level certification is in operation it will be advisable for the customer to conduct periodic quality audits of the material being shipped. Such action will provide assurance that the program is being properly carried out. It will further reveal damage to goods in shipment either because of poor packaging or rough handling by the carrier.

Quality Level Certification is possible if the supplier is equipped to handle the program. He must have an active and effective statistical quality control program in operation.

He must have his manufacturing processes under control. He must be able to speak the language of the Quality Control Engineer. By visiting the vendor's plant you should be able to tell whether or not he is ready for consideration as a participant in a quality level certification agreement.

The post-war growth of modern quality control has been outstanding. The application of quality control methods to manufacturing has rapidly increased. However, if we were to take inventory, we would find a large portion of industry unfamiliar with these methods. A good many companies are just beginning to become interested. This is not surprising. The old saying that "Rome was not built in a day" still holds true. For this reason the acceptance of quality level certification as an essential technique for controlling the quality of purchased material will be slow in developing.

The company that develops a sound and practical certification program will open up new advertising channels for its products. Guaranteed quality means greater sales appeal. Some companies have already advertised in trade journals with headlines announcing the benefits of statistical quality level certification.

In summary, Quality Level Certification is based on:

1. Objective specifications adequately graded.
2. Efficiently engineered inspection procedures adequately recorded for transfer to the shop and the vendor.
3. Standardized measuring methods.
4. Practical quality levels satisfactory both to vendor and customer.
5. Statistical quality control evidence authentically endorsed and supplied with each shipment.
6. Quality audits.

AN ALTERNATE TO QUALITY LEVEL CERTIFICATION

Control of the quality of purchased material is essential to economic manufacturing and satisfactory outgoing quality levels. If Quality Level Certification, as we have discussed it, cannot be employed as a control at this time what alternate methods can be employed? Such a question is in order. Let us see what quality control has to offer in answer to the question.

The standard receiving inspection program is by necessity one of acceptance sampling. The cost of one hundred percent inspection is prohibitive. Therefore, we must resort to a receiving inspection program based on a sample taken from the shipment. We must inspect the sample and decide from the evidence provided by the sample whether the shipment should be accepted or rejected.

It is obvious that some specification as to what we mean by good material is essential to any acceptance sampling program. What we have said regarding specification still holds true. Inspection operation methods and standardized measuring techniques are also necessary.

Sampling inspection involves risks. The quality of the uninspected portion of the lot is never truly known. We could take a sample of 900 out of 1000 parts received, and unless we checked the 100 left uninspected, we would never definitely know the true quality of the lot. Whether we like it or not it is only common sense to decide to tolerate some proportion of non-acceptable material.

Since we are forced to take risks in sampling to determine quality we should be fully aware of what those risks are and then control them. Quality control enables us to do this. Formal sampling procedures have been developed and are available in books and pamphlets at a small cost. The most widely used sampling programs are "Single and Double Sampling" as developed by Dodge and Romig, "Sequential Analysis" and "Sampling Inspection" by the Statistical Research Group, Columbia University, and Dorian Shainin's "Lot-Plot Method."* Programs tailor-made to your needs can be developed by a competent quality control engineer.

Formal sampling programs give definite quality protection. Do not be lulled into thinking that these plans are nothing but fancy percentage inspections. The widely used percentage inspection is performed without recognizing the probability of error and without consideration of any definite quality level. Its protection value is too often poor and its cost too high. This is not true of formal acceptance sampling based on statistical methods.

* To be published soon in IQC.

The degree of success obtained from a quality control acceptance sampling program will be dependent on the cooperation you get from your purchasing department and your engineering department. When rejections are made because the material does not meet quality standards, Purchasing must honestly try to bring about corrections. When specifications are found to be impractical, and out of line with what is actually needed, or can be produced, Engineering must be willing to revise the standards. A good way to promote this cooperation is to collect all added costs originating from the forced use of sub-standard material and assign them to the operating overhead of the department responsible for correction. Thus if Purchasing fails to procure good material, excess cost derived from having to use such material would reflect itself in their cost statement. Purchasing will undoubtedly declare such methods vicious. Whether or not this is true will not be discussed here.

Quality levels selected for receiving inspection should be based on the same factors mentioned relative to Quality Level Certification.

In a way, Receiving Inspection using formal sampling procedures can be regarded as Quality Level Certification by one's own inspection. Many companies are now employing this type of certification. By so doing they are laying valuable ground work for possible certification of quality by their vendors.

Vendors who find themselves constantly in trouble regarding the quality of their product can correct the trouble if they will only adopt modern quality control methods and apply them to their manufacturing processes. This has not been done in a good many companies because there is a feeling on the part of such companies that quality control is not adaptable to their particular type of product. Quality control is now being used successfully in all types of manufacturing from rug weaving to making automobiles. It can be adapted to job shops just as well as to mass production shops. It will control people as well as machines. Remember, a controlled product is a more saleable product. Competition is not only demanding price-cuts but is also requiring better quality. Quality control will help you meet the challenge successfully.

Organization
American Society For Quality Control

RALPH E. WAREHAM, *President*

Since its formation in February, 1946, the American Society for Quality Control has achieved a steady and rapid growth. From 17 local societies taking part in the organizational meeting, the Society has grown to 40 Sections with a membership of 3500. The Society is incorporated as a non-profit, membership corporation under the laws of the State of New York and has a comprehensive constitution and by-laws.

The present leaders of the Society, with photographs, are listed in the following pages.

As provided in its constitution, the Society has established the Advisory Council to lend advisory aid and assistance to the President, the Board of Directors, and the Executive Committee. They have served loyally since the beginning of the Society; their photographs are shown first.

The elected officers of the Society are the President, Vice-President, Executive Secretary, and Treasurer. They, together with the Chairman of the Editorial Board, the Junior Past President, and a Regional Director, each representing a specific geographic region of the country, form the Executive Committee. They are shown on the second page of photographs.

The Regional Directors are elected by the National Directors of the Region from among their own number. Present Regional Directors represent Society Sections as follows:

New England Region—Boston, Hartford, New Hampshire, Southern Connecticut, and Western Massachusetts.

Middle Atlantic Region—Baltimore, Delaware, Metropolitan, Philadelphia, and Washington.

Northern Region—Buffalo, Greater Muskegon, Michigan, Mid-Hudson, Rochester, Southern Tier, Syracuse, and Toronto.

Central Region—Cincinnati, Columbus, Dayton, Erie, Georgia, Ohio, Pittsburgh, Tennessee, and Toledo.

Midwest Region—Chicago, Denver, Illinois, Indianapolis, Iowa, Milwaukee, Minnesota, Muncie, Northeastern Indiana, Rock River Valley, South Texas, and St. Louis.

Western Region—California.

The National Directors, of which there are 40, represent the Sections on the Board of Directors. They are listed next, alphabetically, within their respective Region.

The Board of Directors is the governing body of the Society, and is composed of the President, Vice-President, Executive Secretary, Treasurer, Chairman of the Editorial Board, Junior Past President, and the National Directors from each Section. Because of its size, the Board of Directors has not found it possible to hold meetings more frequently than once each year, usually at the Annual Convention of the Society.

During interim periods, the Executive Committee acts for the Board of Directors. The Executive Committee holds numerous meetings during each Society year and establishes Society policy, subject to review by the Board of Directors. Each Regional Director brings to the Executive Committee problems and plans of his constituent Section and in turn reports back to the National Directors in his Region, concerning important actions taken by the Executive Committee and basic plans for the Society's activities. Attendance at Executive Committee meetings has been excellent with usually 10 or 11 of the 12 members present.

The President of the Society is Chairman of the Board of Directors and of the Executive Committee; the Executive Secretary is Secretary of both bodies.

The 40 Sections of the Society are the key links, binding our Society into a National organization. The Sections develop Quality Control in their respective areas and serve as clearing houses for important Quality Control information and developments.

The key man in each Section is the Section Chairman, or President, as he is titled in the Midwest Sections, who organizes the work of his group to achieve the purposes stated above and who directs the works of all Section officers and Committees. Photographs of these men are shown following the National Directors.

The Editorial Board, whose photographs are shown next, is responsible for editorial administration of the magazine and all other technical publications of the Society. Members of the Editorial Board are appointed by the President with the approval of the Board of Directors and serve as the operating body for all Society publications, the principal one being the magazine. It is mailed to each member of the Society in January, March, May, July, September, and November, as one of the privileges of membership. Libraries and like institutions may subscribe to it.

The Society now has two honorary members and one Shewhart Medallist. A second Shewhart Medal and the first Brumbaugh Award will be presented at the Milwaukee Convention. The individuals so honored are listed at the conclusion of this section.

During the past four years, many steps have been taken by the Society groups to stimulate and assist in the development of modern methods of Quality Control throughout the United States and Canada. With these developments, increasing recognition has come to the Society from other technical fields. Industry and Business are rapidly accepting and adopting these modern methods.

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*E. H. Robinson—Editor I.Q.C. News Supplement.

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"have rendered eminent service to Quality Control."

BRUMBAUGH AWARD

LEONARD A. SEDER
National Director

will receive the first Brumbaugh Award at the Fourth National Convention in Milwaukee.

for the excellence of his paper, "The Technique of Experimenting in the Factory," published in *INDUSTRIAL QUALITY CONTROL, March, 1948.*

SHEWHART MEDALLISTS

LESLIE E. SIMON
Member of Editorial Board

was awarded the first Shewhart Medal at the Third National Convention in Boston.

"in recognition of his pioneer achievements in the development and use of Statistical Quality Control . . ."

HAROLD F. DODGE
Member of Editorial Board

will be the recipient of this medal at the Fourth National Convention in Milwaukee.

"an individual noted for outstanding leadership in the field of modern Quality Control . . ."

Remember?

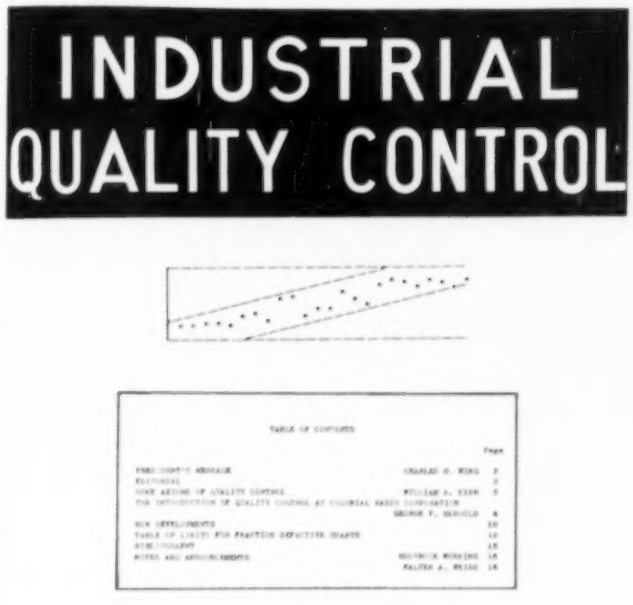
The cover of Vol. I. No. 1, of INDUSTRIAL QUALITY CONTROL, issued July, 1944, is reproduced here.

Martin A. Brumbaugh, then Vice-President of the Society of Quality Control Engineers, of Buffalo, New York, was the Editor. The other officers of this group were: Charles H. Wing, President; Vernon Grom, Secretary; George V. Herrold, Treasurer.

The Society of Quality Control Engineers of Buffalo became the Buffalo Section of the American Society for Quality Control when the latter was organized in February, 1946. INDUSTRIAL QUALITY CONTROL became the official publication of the new Society, and Martin Brumbaugh became Chairman of the Editorial Board. Through his efforts, the magazine increased from 16 pages to 32 pages and became a most valuable Quality Control publication.

Mason Wescott succeeded Martin Brumbaugh as Chairman of the Editorial Board in July, 1947, and further improvements have been made under his guidance.

These men have made an outstanding contribution to Statistical Quality Control.


INDUSTRIAL
QUALITY CONTROL

SOCIETY OF QUALITY CONTROL ENGINEERS
IN COOPERATION WITH
THE UNIVERSITY OF BUFFALO
VOL. I JULY 1944 NO. 1

Quality Control begins with Research

World's Largest Research Center for Building Materials and Asbestos Products—Manville, N. J.

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"Time is the measure of business"

Sir Francis Bacon

To operate at the most efficient level each minute of the day is the aim of business. In these times of complex organization, most businesses require mechanical means to help realize the full value of time.

Accounting and statistical reports—inclusive, well-organized and accurate—which make possible important decisions without delay, are supplied by IBM Electronic and Electric Accounting Machines.

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IBM Electric Typewriters bring speed and flexibility to typing, and save time and effort for other tasks.

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"TO COUNT IS TO CONTROL"
QUALITY–
PRODUCTION–SERVICE

COUNT ON VEEDER-ROOT

Mechanically...

Strokes, revolutions, pieces, volumes, lengths . . . or other units of performance and production . . . can be counted by Veeder-Root Mechanical Counters like this new General-Purpose No. 1260. This direct-reading, streamlined counter counts up to 1,000,000 . . . then resets (unless you want to reset it sooner) with one turn of knob. And it's *compact,* so it can be *built into* most machines and products, to add utility and marketability.

Magnetically...

To report machine output direct from plant to office . . . or to count units of a size or weight that makes them tough to count mechanically . . . count on these new Veeder-Root Reset Magnetic Counters, No. 1205 for AC, No. 1248 for DC. Easy to install on regular light circuit . . . widely used with "electric eye." And they may be grouped on panels, at any distance from the machines they report on.

Manually...

To count people, poles, shrubs, blood-corpuscles, cars, ticket-buyers . . . or anything that can't be counted mechanically or magnetically . . . count on this No. 1023 Hand Tally that fits both hand and pocket. To count one, press thumb-lever once. When count is complete, turn reset knob, start over from zero. Ends errors from memory-count and pencil tallies.

These are only 3 of the scores of types of Veeder-Root Standard and Special Counters. Most likely you, too, can count on Veeder-Root, to your profit. Write.

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Acknowledgments

R. S. SADDORIS, General Chairman, Planning Committee

The success of any venture depends upon the cooperative effort of all of those associated with that undertaking. The good that will come from this Fourth National Convention and Fifth Midwest Quality Control Conference will be because of the hard work that all have contributed to help it into being.

As General Chairman of the Planning Committee I want to thank first the members of that committee for their tireless and unselfish efforts. They have worked as a team. There have been the expected differences of opinion, but when these came up they were quickly resolved and all of our actions have been of unanimous agreement in the committee. Many of these men have traveled long distances at frequent intervals to attend our meetings. These trips have broken up their week-ends; they have been difficult to attend at times. The employers of our committee members have been most generous in permitting their employees to give of their companies' time in order that we might do the best job possible. This committee wants to express its appreciation to those employers; to business and industry; to the Midwest Sections, and to all of the Sections of the American Society for Quality Control for their splendid cooperation.

CONVENTION ISSUE

We are indebted to so many that we hesitate to name a few, but at the risk of omitting some of our acknowledgements we want to thank as many as possible. First let us consider this convention issue of our magazine. It has been made possible with the support of our regular advertisers, most of whom have advertised with us from the earliest editions, and also with the enthusiastic support of industrial users of quality control. The committee first considered publishing a souvenir program of the convention and planned to enlist the support of industries using quality control to finance the cost of such a publication. Such a program would have been available for distribution only at the Convention, whereas this magazine will be delivered to our readers prior to and at the Convention. Approval of the Editor and of the Executive Committee was necessary before we could do what we have done here. This was quickly given.

ADVERTISERS

Those industries which are known to be interested in Statistical Quality Control and which have been most helpful in supporting and expanding these methods were invited to place advertising in this issue. The results are evident in the many pages of such advertising. We suggest that you read each of them carefully. They mark the advertiser as a progressive leader in his industry. Other companies are following their example, indicating the rapid acceptance of Statistical Quality Control by Industry and Business.

But even with this support, this issue would have been less effective without the efforts of your Editorial Board and your officers in stepping up the publication date so that you might receive the magazine near the first of the month of publication. This has meant a great deal of work to many and they are to be commended for this achievement. Mason Wescott, Fred Halton, and Wade Weaver have carried the brunt of this work.

A.S.Q.C. ORGANIZATION

Another feature in this issue is the section devoted to those who are presently active in the affairs of the American Society for Quality Control. It is hoped that this will help you become better acquainted with the people who are giving so much of their time and energy for the furtherence of the principles of the Society. They are serving with no remuneration other than that of the satisfaction of being associated with a progressive movement and of a job well done. As this year draws to a close, they will be replaced by others equally zealous and equally progressive. They are doing the thousand and one little detail jobs that must be done if our Society is to continue to grow as it has done so rapidly since its formation four short years ago. Learn to know these men. Help them to help you.

The work of compiling the information, obtaining the photographs, and preparing the copy for publication has been no small task. Much of the credit for this work goes to Ralph Wareham, Simon Collier, and Professor William A. MacCrehan.

EXHIBITS

Another feature of the magazine is that section devoted to exhibits. The committee headed by Sam Ouweneel has endeavored to furnish the best possible facilities for displaying the very latest gaging methods, business machines, and systems which are available for better control of quality. In order that you may know what to look for when you arrive at the Convention, a short preview of the exhibits is given in this section. We regret that all exhibitors are not included therein. All were invited to participate, but the closing date for publication of the magazine apparently was too early to enable all of them to prepare suitable copy. Do not fail to visit all of the exhibits at the convention. Remember that they are there to help you.

PROGRAM

Elsewhere in this issue you will find the complete program. Study it carefully. There is something of interest to each and every one of you. Come prepared to take advantage of the experience of the men conducting these sessions. Note that they represent many industries and are from every section of the country, making this a truly national effort. Lloyd Knowler is responsible for assembling this corps of men from industry and education.

TRANSCRIPTS

You will also want to obtain the transcripts of the complete papers as they are presented at the convention. Mason Wescott and his committee have made them available to everyone.

SPECIAL EXHIBITS

Special thanks go to the Armed Forces and to those companies who have made possible the educational exhibits showing quality control at work. You will see the actual production of parts and the application

(Continued on page 60)

ANNOUNCING THE
Fourth Annual Convention
American Society For Quality Control

Milwaukee Auditorium, Milwaukee, Wisconsin

EDUCATIONAL SESSIONS

Chairman

PROFESSOR EDWIN G. OLDS
Department of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pennsylvania

Panel Members

PROFESSOR C. C. CRAIG
Department of Mathematics, University of Michigan, Ann Arbor, Michigan

PROFESSOR I. W. BURR
Department of Mathematics, Purdue University, Lafayette, Indiana

PROFESSOR J. A. HENRY
Department of Mechanical Engineering, University of Illinois, Urbana, Illinois

DR. CARL E. NOBLE
Quality Control Engineer, Kimberly-Clark Corporation, Neenah, Wisconsin

Thursday, June 1, 1950

9:00 A.M.
Orientation Session

2:30 P.M.
"What Is Statistical Quality Control?"
Professor E. G. Olds

4:10 P.M.
"Interpreting Industrial Data"
Professor C. C. Craig

Friday, June 2, 1950

9:00 A.M.
"Using Charts For Process Control"
Professor J. A. Henry

10:40 A.M.
"Fundamentals Of Acceptance Sampling"
Professor I. W. Burr

2:30 P.M.
"Standard Sampling Tables"
Dr. C. E. Noble

4:10 P.M.
"Putting Statistical Quality Control To Work"
Professor E. G. Olds

GENERAL SESSIONS

Thursday, June 1, 1950

10:30 a.m. OPENING ASSEMBLY, *Plankinton Hall*
CHAIRMAN: R. S. Saddoris
WELCOME: Hon. Frank P. Zeidler, *Mayor of Milwaukee*

CONVENTION HIGHLIGHTS
Frederick J. Halton, Jr., *Midwest Regional Director*
Ralph E. Wareham, *President, ASQC*

12:15 P.M.—Informal Luncheon-*Market Hall*

2.30 P.M.—Clinic Session 1A
SUBJECT: "Some Possible Contributions of Statistical Quality Control to Engineering Economy"
SPEAKER: Eugene L. Grant, Professor of Economics of Engineering, Stanford University, Stanford, California
MODERATOR: J. N. Berrettoni, Senior Partner, Berrettoni and Associates, Minneapolis, Minnesota

4:10 P.M.—Clinic Session 2A
SUBJECT: "Quality Control of Jet Aircraft Components"
SPEAKER: William C. Lee, Chief Inspector, Solar Aircraft Company, Des Moines Plant, Des Moines, Iowa
MODERATOR: Henry J. Jacobson, Quality Control Engineer, Western Electric Company, Chicago, Illinois

2:30 P.M.—Clinic Session 1B
SUBJECT: "Specification, Measurement, and Control of Quality"
SPEAKER: A. G. Dalton, Superintendent of Quality Control, Western Electric Company, New York, New York
MODERATOR: Halmond L. Parks, Director of Quality Control, Ball Brothers, Inc., Muncie, Indiana

4:10 P.M.—Clinic Session 2B
SUBJECT: "Statistical Quality Control in the Foundry"
SPEAKER: George VerBeke, Quality Control Engineer, Union Malleable Iron Works, Deere and Co., East Moline, Illinois
MODERATOR: Walter J. Harms, Camcar Screw & Manufacturing Company, Rockford, Illinois

All time is Central Standard Time

AND THE

Fifth Annual Midwest Quality Control Conference

Thursday and Friday, June 1-2, 1950

7:00 P. M.—ANNUAL CONVENTION DINNER MEETING, ASQC

Hotel Pfister

CHAIRMAN: Ralph E. Wareham, President ASQC

CEREMONIES: (1) Awarding of the Shewhart Medal to the 1949 Medalist

(2) Awarding of the first Brumbaugh Award

Friday, June 2, 1950

9:00 A.M.—Clinic Session 3A

SUBJECT: "The Role of Statistical Quality Control in Air Force Procurement"

SPEAKER: M. H. Pardee, Captain, USAF, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio

MODERATOR: William F. Kirschbaum, Jr., Inspector Supervisor, Inspector of Naval Material, Fort Wayne, Indiana

9:00 A.M.—Clinic Session 3B

SUBJECT: "Measurement and Control of Flavor Quality"

SPEAKER: David R. Peryam, Chief, Acceptance Division, Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois

MODERATOR: E. Russell Meyer, Supervisor of Quality Control, Caterpillar Tractor Company, Peoria, Illinois

10:40 A.M.—Clinic Session 4A

SUBJECT: "Balancing and Randomizing in Experiments"

SPEAKER: Warren R. Purcell, Manager of Quality Control, Lighting Division, Sylvania Electric Products, Inc., Salem, Massachusetts

MODERATOR: C. H. Bone, Assistant Works Metallurgist, Sheffield Steel Corporation, Houston, Texas

10:40 A.M.—Clinic Session 4B

SUBJECT: "Acceptance Inspection"

SPEAKER: A. C. Richmond, General Supervisor, Inspection Methods Research, Manufacturing Research, International Harvester Company, Chicago, Illinois

MODERATOR: Paul K. Leatherman, Director of Quality Control, Lambert Pharmacal Company, St. Louis, Missouri

12:15 P.M.—Luncheon Meeting

SUBJECT: "What Management Expects from Quality Control"

SPEAKER: Lewis D. Crusoe, Vice President, Ford Motor Company, General Manager, Ford Division, Dearborn, Michigan

2:30 P.M.—Clinic Session 5A

SUBJECT: "Installing a Complete Quality Control System"

SPEAKER: Stanley C. Amren, Director of Quality Control, The United States Time Corporation, Waterbury, Connecticut

MODERATOR: H. S. Bicknell, Supervisor of Quality Control, The Maytag Company, Newton, Iowa

2:30 P.M.—Clinic Session 5B

SUBJECT: "Statistical Quality Control of Clerical and Manual Operations"

SPEAKER: James M. Ballowe, Manager of Inspection, Aldens, Inc., Chicago, Illinois

MODERATOR: Dale L. Lobsinger, Quality Control Engineer, United Air Lines, Denver, Colorado

Wisconsin does not have Daylight Saving

of statistical methods in the control of their quality. You will also see the series of charts that Ralph Foley has assembled, showing applications of Statistical Quality Control in numerous plants.

PROMOTIONAL ASSISTANCE

We thank the Wisconsin Manufacturers' Association for timely and valuable assistance given us; for recommending the Convention to their own members and to 38 other similar associations throughout the nation. The Milwaukee Association of Commerce has been most helpful in the planning of the Convention and in handling the registration and housing problems.

The Industrial Management Institute of the University of Wisconsin has rendered valuable assistance. Added help has also come from Marquette University, the Mayor of Milwaukee, the Governor of Wisconsin, and the State Conservation Department.

The Auditorium Board and the operating staff of the Milwaukee Auditorium, with their vast experience in handling much larger conventions than ours, have made the task of Les Eichelberger and his Arrangements Committee much lighter.

The small stickers, "Meet Me in Milwaukee" which were attached to many thousands of letters mailed from business offices throughout the country have helped to call this Convention to the attention of many who might not have been otherwise contacted. Thank Bob Hermann's committee for them and for the excellent job of promoting the Convention.

Finally, we acknowledge our debt to those who have conducted past conventions and conferences. We have relied heavily upon their experience, without which our problems would have been much more difficult.

THE CONVENTION PLANNING COMMITTEE

General Chairman
R. S. Saddoris
A. O. Smith Corporation
Milwaukee, Wisconsin

Secretary-Treasurer
Larry Hammond
Larry Hammond Company
Milwaukee, Wisconsin

Budget
Warren E. Jones
Management Controls
Des Plaines, Illinois

Vice-Chairman Program and Exhibits
S. W. Ouweneel
Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

Program
Lloyd A. Knowler
State University of Iowa
Iowa City, Iowa

Proceedings
Mason E. Wescott
Northwestern University
Evanston, Illinois

Vice-Chairman, Promotion
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Printing
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International Harvester Co.
Milwaukee, Wisconsin

Vice-Chairman, Arrangements
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A. O. Smith Corporation
Milwaukee, Wisconsin

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Huebsch Mfg. Co.
Milwaukee, Wisconsin

Reception
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Waukegan, Illinois

Convention Facilities
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South Texas

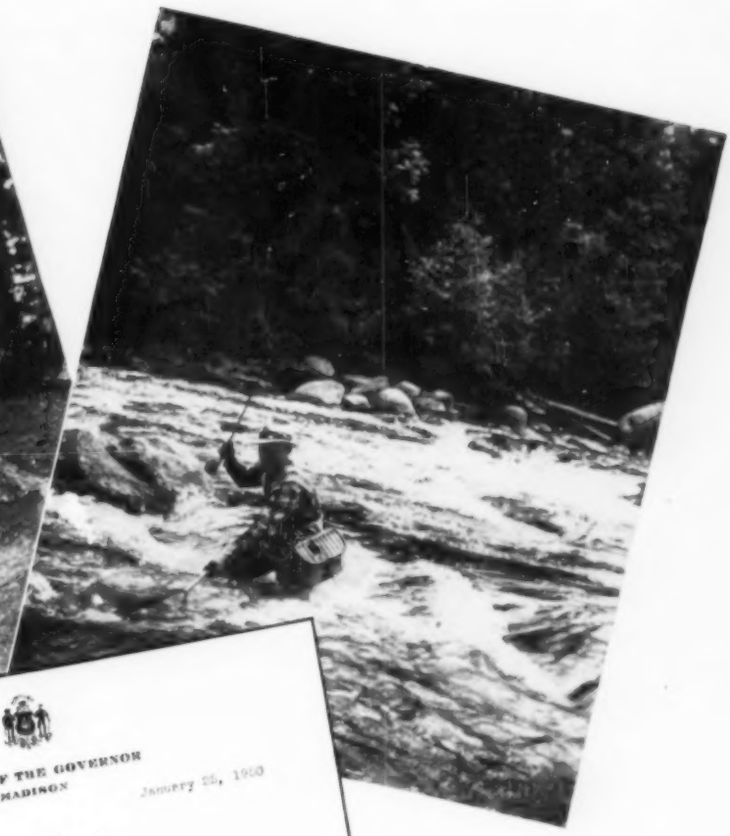
With the Cooperation of

The Milwaukee Association of Commerce

The Wisconsin Manufacturers' Association

HIGHLIGHTS OF THE CONVENTION

The Opening Assembly
The Working Demonstrations
The Exhibits
The Clinical Sessions
The Educational Sessions
"What Management Expects of Quality Control," Lewis D. Crusoe, V. P. & Gen. Mgr., Ford Division
The Annual Banquet



OFFICE OF THE GOVERNOR
MADISON

January 25, 1960

OSCAR RENNEBOHM
GOVERNOR

Mr. R. S. Saddoris, General Chairman
Fourth National Convention
Fifth Midwest Conference
American Society for Quality Control
P.O. Box 1204
Milwaukee 1, Wisconsin

Dear Mr. Saddoris:

I am happy to have this opportunity to welcome to the state of Wisconsin the National Convention of the American Society for Quality Control.

My own private business experience has made me familiar with the work of your members. I hope that your assembly at Milwaukee will produce much productive information about statistical methods for controlling quality.

We who live in Wisconsin take great pride in the varied recreational activities available to our visitors. I hope that many of those who attend this national meeting find it possible to remain with us for a few days after you have completed your business to enjoy the tremendous natural blessings which have been bestowed upon our state.

Please accept my sincere hope that your meeting here in Wisconsin will be a profitable one and that Wisconsin hospitality meets with your unqualified approval.

Sincerely yours,

Governor

Photos courtesy Wisconsin State Conservation Department.

Spend more time at the

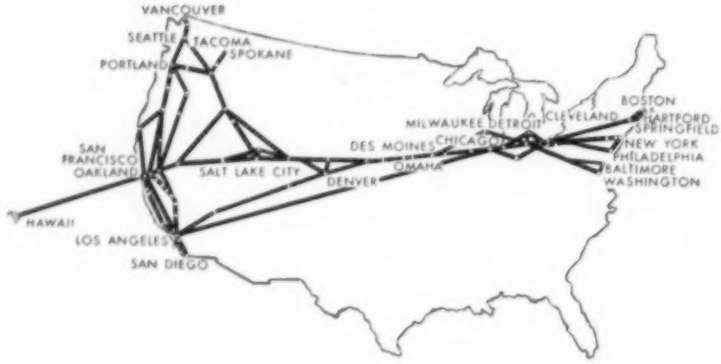
Convention . . . less time getting there!

FLY UNITED TO MILWAUKEE

American Society for Quality Control—June 1-2

Swift United Mainliners put Milwaukee within a few hours of 80 cities on the Main Line Airway. Enjoy this faster, finer way to travel—and you'll find it economical, too with no extra expenses aloft.

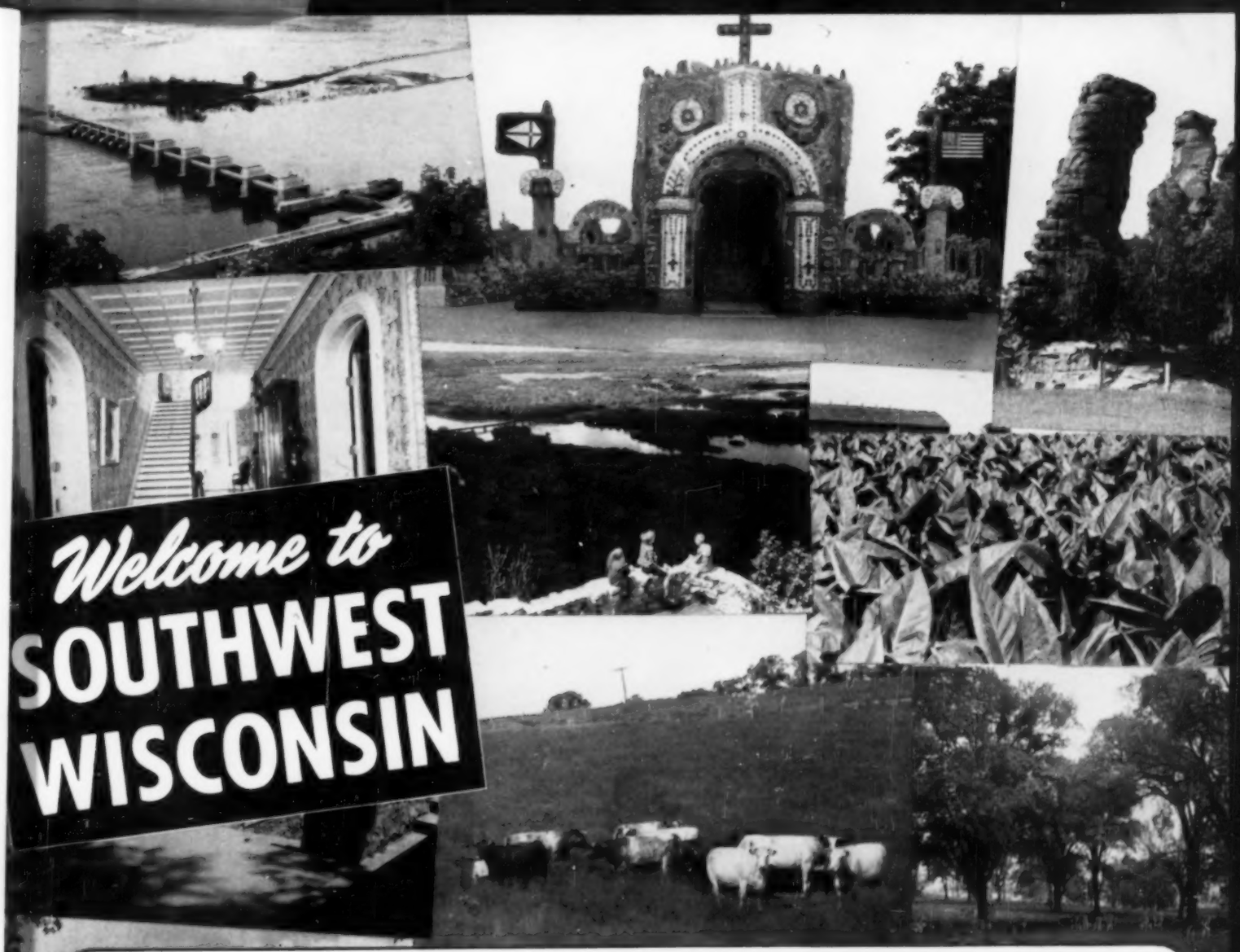
● And if you're planning to take the family—don't forget to get details on United's Half-Fare Family Plan and perhaps combine a vacation with business. For information and reservations call United or an Authorized Travel Agent.



UNITED AIR LINES

QUALITY CONTROL METHODS Improve United's *"Service in the Mainliner Manner"*

En route to Milwaukee on United, you will have a first hand view of some of the end results of quality control methods as applied to certain airline problems. The reservations procedure through which you obtained your ticket, the meal you enjoy aloft, and other functions aloft and on the ground have been improved through quality control. Progress has been rewarding . . . and this work continues.



VISIT THE LAND THE GLACIERS FORGOT!

CENTURIES AGO, during the "Ice Age," great passing glaciers wrote with grinding granite the history of their passing on the rocks that barred their paths. The general result was a disturbance of scenic beauty as Nature made it.

Such disturbance is not noted in Southwest Wisconsin because, fortunately, it did not lie in the path of the glaciers. Yes, the scenic beauty of this un-glaciated section of Wisconsin remains today as it has been since the beginning of time.

Rare beauty, awe-inspiring beauty, beauty that is unmatched anywhere else in the state. You may look upon rivers flowing through gorges, or watch the spectacle of white-frothed waterfalls and hurrying rapids. There are towering columns of rock that look majestically down on twinkling streams; there are quiet valleys untouched by the hurrying world; at every turn, new scenic beauty abounds in Southwest Wisconsin.

Throughout Southwest Wisconsin there are many historically important monuments, standing as tribute to the explorers, fur traders, trappers, loggers and pioneer settlers who wove the mantle of romantic conquest about this territory.

Southwest Wisconsin is, indeed, one place which offers the entire family the kind of vacation it wants. Whether they seek fishing, boating, hiking, riding, sports, swimming, exploring, or just carefree days of pleasant idleness, Southwest Wisconsin will please them.

Plan to come to Southwest Wisconsin this year. Come for a week or a week-end. Hospitality awaits you, the latchstring is out. Welcome!

SOUTHWEST WISCONSIN SCENIC ASSOCIATION

ELLIS A. LEE, *Secretary*, Richland Center, Wis.

Write to Secretary for Beautiful 40-Page Booklet Describing the Area. It's Free!

GREAT CARS SINCE 1902 !

NEW Nash Airflyte RAMBLER

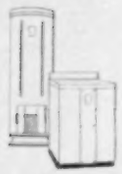
The nation's newest motor car and the world's first safety convertible bears one of the most honored names in automotive history. The Rambler was one of the very first mass-produced cars—'way back in 1902. The new 1950 Nash Rambler Convertible Landau is worthy to carry this famous name.

SEE ALL THREE NASH AIRFLYTES

The Ambassador • The Statesman • The Rambler

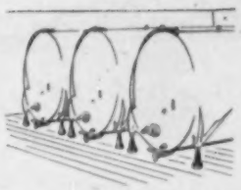
Nash Motors

DIVISION, NASH-KELVINATOR CORPORATION, DETROIT, MICHIGAN



Automatic Water Heaters for the Home

Automatic Water Heaters for Large-volume Users



Glass-lined Tanks for Brewers and Industry

Harvestores for Storage of Farm Feed Crops

14,750 Pounds of Steel *per minute!*

A. O. Smith Corporation, in conservative figures, uses steel at an average rate of 14,750 pounds per work-day minute . . . more than 7 million pounds each 24 hours. "Raw" steel flows into A. O. Smith's six plants, and comes out in the form of the products pictured here.

Many of these products are designed for industrial service throughout the world, though rarely seen by the public. Others, such as the *Permaglas, Duraclad, Milwaukee,* and *Burkay* brands of automatic water heaters, are known in homes and small businesses throughout the nation.

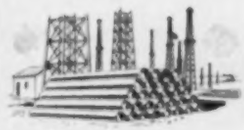
At A. O. Smith progressive engineering, comprehensive research, and unique manufacturing methods are joined to make products designed to give the maximum in dependable service in the home, on the farm, and in industry.

A.O. Smith 76th Anniversary 1874 · 1950

A.O.Smith
CORPORATION

Factories at Milwaukee, Kankakee, Houston, Toledo, Los Angeles, Succasunna, N. J.

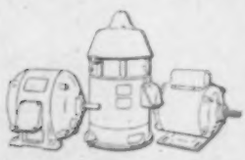
Large-diameter Pipe for Cross-country Pipe Lines



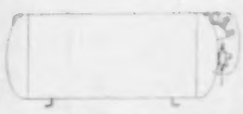
Casing Pipe for Oil Wells and Deep Water Wells

Vertical Turbine Pumps for Irrigation, Municipalities, Industry

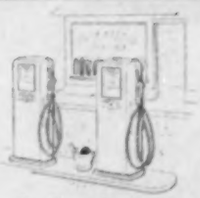
Electrodes, Welding Machines, and Welding Equipment



Electric Motors for Standard and Special Uses



Liquid Gas Systems for Home, Farm, and Ranch



Gasoline Dispensing Pumps and Petroleum Meters

Pressure Vessels for Refinery, Papermaking, and Chemical Service

East of the River and West of the Lake!

Four blocks west of beautiful Lake Michigan, the PFISTER is in the East downtown section of MILWAUKEE. Convenient, comfortable and interesting—it is the home of the nationally famous English Room—and of a Nineteenth Century group of paintings on permanent display. Whether you stop at the Pfister during your June convention or whether you are here for the banquet only, members of Quality Control, we invite you to look at our paintings. An art catalog is available at the desk.

HOTEL PFISTER

424 East Wisconsin Avenue
Ray Smith, Jr., Manager

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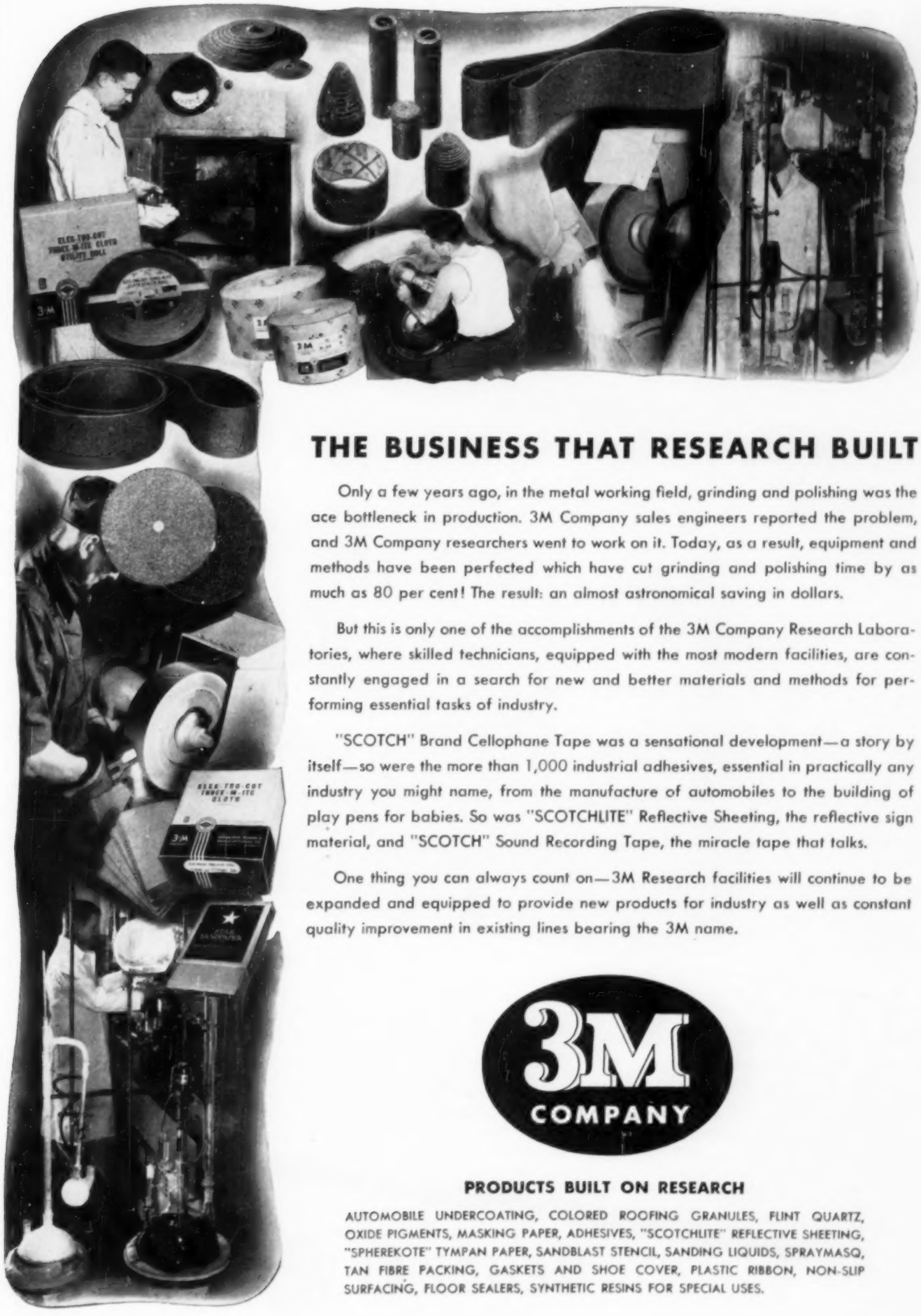

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GENERAL ELECTRIC

687-36

Improving Vendor-Consumer Relationships*

EDWARD M. SCHROCK

Quality Control Engineer, Household Refrigerator Division
General Electric Company, Erie, Pennsylvania

THE CONSUMER'S RESPONSIBILITY FOR QUALITY

A high quality product economically produced must start with uniformly acceptable raw materials. In creating a situation in which the raw materials are uniformly acceptable, the first and prime responsibility rests with the consumer. The first steps to be taken are steps which he must take.

First, the consumer must have a sound specification. He must be certain that the quality characteristics for which he asks are really necessary for the further processing of the material in his plant or for the satisfaction of the customer. He must be sure that what he is asking for is something that can be produced economically. He must be sure that the relationship between the processes producing that material and the specification are sound.

Secondly, the consumer must be sure that the vendor is fully informed of his needs. This may be provided for in three ways:

First, by way of written instructions. The drawings, for example, which are supplied to the vendor should indicate those quality characteristics that are required and their relative importance. Those things which are critical, major, or minor should be so designated. It has been our practice to indicate on the drawing a standing instruction number which is our own internal specification. That specification is supposed to accompany the drawing when it goes to the vendor. If by any chance it does not go out or becomes separated from the drawing, the presence of that number on the drawing is the vendor's signal to ask for a copy of that specification. In that specification there will be indicated acceptable quality levels for various characteristics, and inspection and test procedures.

Secondly, it is highly desirable at times to visit the vendor personally after arrangements have been made for such a visit through the Purchasing Department in order to be sure that he understands what you have written down. Try as we may to make things simple and clear, sometimes the thing that seems simplest to us is the most confusing to somebody else. Nothing will ever take the place of personal visits, face to face discussions with the vendor about specific quality desires and interests. Such visits will also provide an opportunity for appraisal of the vendor's equipment and manufacturing situation. It will provide an opportunity to see what kind of housekeeping he does. While in itself not a direct vital consideration, it is frequently an index to the type of workmanship that may be expected from that manufacturer.

Thirdly, the vendors' visits to you. These will fall into two categories: First, those which are made as a matter of routine by those vendors with whom you do a great deal of business. Frequently such vendors will have a representative at your plant a substantial part of the time. We are here more concerned with a second type of vendor visit to the consumer, namely, a vendor education program.

Some of you may have seen the report entitled "Industrial Project in Statistical Quality Control" issued June 30, 1948 by Edward A. Reynolds and Gertrude M. Reynolds.* The project was conducted in the Syracuse area in cooperation with Syracuse University and the Syracuse Section of ASQC, and was aided by an appropriation from the United States Department of Commerce. I would like to indicate first from this report the nature of the companies that attended the opening session of the program a year previous to that time on which occasion a dinner meeting was arranged for top management people. Three-hundred-ninety-six companies in Onondaga County were involved in this initial survey. Of these 396, forty-eight were in the category of having 200 employees or more. Three-hundred-forty-eight had less than 200 employees. The number of companies represented at that meeting was 25 out of the 48, or 52% of the larger companies. Twelve of the 348, or 3.4% of the small companies were represented. That is a very striking contrast. It appears that interest in the smaller companies is not at the level of intensity of the interest in the larger companies.

One of the comments made in the report was that the "discussions with general managers and quality heads indicated that over three-fourths of the men in small companies had never heard of statistical quality control. In the larger organizations about one-third had never heard of it, about one-third had heard of it and were quite sure it had no use in their type of production, and about one-third had heard of it and had some degree of interest in its possibilities." At the start of this program, only seven of the 396 manufacturers in Onondaga county were using any form of statistical quality control and only one of these was using the methods extensively. Most of the management executives had either not heard of statistical quality control or else had received an erroneous idea of its purposes. In Mr. Reynolds' opinion two-thirds of the plants visited had worthwhile opportunities for application of statistical controls. Although there was initially little demand for training, after a management meeting 205 employees enrolled

*Paper presented to Third Annual Convention, ASQC, Boston, May 5, 1949.

*See July, 1948, issue of IQC for a summary of this report.

in the project's eight training courses. Approximately 90% of employees completing such training courses desired additional training for themselves and for others in their companies.

"All results of this project indicate that training programs in statistical quality control are worthwhile in an industrial area. However, it is believed the main barrier to increased use of this method is managements' unfamiliarity with its benefits, rather than lack of either opportunities for its use or trained personnel to put the methods into effect. Special emphasis should, therefore, be placed on such management training."

To my mind that report is one of the high spots in recent activity in quality control for it points the finger directly at the major problem with which we are faced today and that major problem is simply ignorance of what can be accomplished by modern quality control techniques in industry. There are two solutions to that situation that we might try. One would be to wait until young men going through technical and engineering schools become educated in this new modern field, get out into industry, and work up to positions of responsibility. That would take a generation or two. A second possibility would be to let things take their natural course of events and hope that these small companies will sooner or later somehow hear about this new modern field and put it in their own plants. Since both of these procedures are slow and time consuming it is recommended that the larger companies who know what modern quality control can do, who have used it to advantage in their own organizations, now assume a share of the task of educating management in smaller companies. Our colleges and universities are making a noble effort in their intensive training programs to get management interested, but they alone cannot do the job with the speed that is called for today. They need our help.

We expect in G.E. this summer (1949), at Erie, to conduct a two day informative program for top management among our vendors.* Invitations will be issued to each one of our vendors that are not now using modern quality control techniques to come to Erie for two days to find out what this thing is all about. We anticipate getting a top man from each company, someone who is in a policy making position so that when he goes back from this course he will be able to decide and follow through with his decision as to what will happen in his plant in putting these techniques to work. We plan to conduct a half day session on control charts for attributes, a half day session on control charts for variables, a half day session on sampling methods, and a half day tour of the plant. We do not propose that these men are going to go back knowing how to put these methods to work personally or knowing all the ramifications that are of importance in using the techniques, but rather it will be our purpose to show them how they can benefit by using these tools so that they may then feel the urgent necessity of selecting someone in their own organization to train technically to work in this field. These men will not, of course, in any sense of the word be quality control engineers when they're through with our two day program, but if they have caught a glimpse of what can be accomplished, certainly the day will be speeded when quality control will be made effective on a large scale throughout our industrial scene.

A program of this sort would not appeal to our vendors if it were only for the purpose of solving *our* quality problems. It would not be of interest to our management if it were only helpful in educating the *vendors*. The beauty of the thing is that it can be helpful to *both* the vendor and to ourselves. Our hope is that ultimately we will be able to reduce greatly the inspection and testing of incoming vendor materials. Other companies are urged, in so far as it is possible and practicable for them to do so, to follow a somewhat similar program according to their own situation with their own vendors. Let us not wait for time to take its natural course and slowly correct this unhappy condition that exists.

A third responsibility that the consumer has is that of conducting a suitable inspection and testing program on incoming materials. Many are undoubtedly familiar with the fact that the vast majority of sampling programs that have been developed by laymen over the years have almost invariably failed to accomplish their intended purpose. They do not provide for the acceptance of virtually all lots which are at an acceptable quality level or better, nor do they provide for the rejection of nearly all lots that are at the lot tolerance or worse.

In so far as possible it is of course recommended that standard sampling tables be used. Unless one is thoroughly familiar with the operating characteristics of the plan to be used, he may go a long way off the mark and fail to accomplish desired results in conducting inspection. It is also recommended that suitable sampling inspection card records be kept of incoming materials so that at anytime it will be possible to appraise the quality of material being received from a vendor.

At the present time we are using a card in one corner of which is reproduced a sampling table for the acceptable quality level applying to that particular item. Cards have been made up for each one of the various acceptable quality levels which we use. It is then possible at a moment's notice to review the record for any given vendor. A record is kept of the date, size of shipment, number of pieces inspected, number of defectives found, disposition of the shipment, and the nature of the principal defects found.

There is a tendency where many quality characteristics are important in an industrial process for the inspection department to get careless about keeping records that will be adequate. Sometimes even though they may be adequate when taken they are not kept properly available. Surely anything that is worth inspecting for the purpose of controling quality is worth recording adequately.

When we began our program, the inspection departments had been following a more or less traditional sampling system in which the risks were not known. We are now using a normal single sampling table that is an extension of the Army Ordnance Table developed during the war. It has been expanded to include lots smaller than 500.

We have utilized single sampling almost exclusively because of a highly congested condition in which we are handling a multitude of different parts in space originally designed for the manufacture of a much smaller volume of material. We anticipate when more normal times arrive that we will make more extensive use of double sampling and sequential analysis. We have used

*This program was held the last week of July. One hundred eighteen representatives of 80 different vendors attended. The program was enthusiastically received and stimulated much interest.

sequential analysis in a few applications but they have been highly restricted because of the conditions mentioned.

Variables quality characteristics of a major nature should be plotted on control charts which can be conveniently reproduced for distribution to the vendor. We are utilizing a Clinton Bond paper on which is printed a master form. On that master chart, with black or India ink, we write the values and plot the control lines and points observed from sample to sample. Our customary procedure is to take a sample of four items from each lot received in shipment and to plot the results of that sample on this form. Any indication of lack of control or the occurrence of a reject according to the specifications in that sample of four immediately calls for an additional sample of at least seven more groups and where possible we get ten more. Those values then, along with the initial results, are used as a separate chart for the purpose of evaluating that lot and making the decision to accept or reject. Copies of this control chart are periodically made available to the vendor and form the basis for discussion whenever quality problems arise.

We anticipate the day when large scale incoming inspection and testing can be abandoned. We have two men following the results obtained on incoming material and who compare the results obtained on our incoming inspection and laboratory tests with results that are certified to us from the vendor. If and when we have a record of six months or more good experience with the vendor and find that we can rely upon his certification we intend to reduce greatly our own incoming inspection and testing. We will always do some as an honesty check and to be sure that some gross error has not been made in supplying the type of part designed, and to be sure that no major slip has occurred in the quality. Until that time arrives, of course, we will continue our regular incoming testing and inspection program.

As a consumer you have a vital responsibility to be sure that your program is on a sound basis so that when you discuss your quality problems with your vendor you may be sure of the nature of the quality you are talking about. This matter of quality is one of the most difficult things that we have to appraise industrially. Superficially it would seem that quality is a simple proposition. To read advertisements and hear some people talk we would think that there wasn't much to it, but when we get down to the problem of specifying quality we find that it is not as simple as it appears on the surface. Sometimes we feel that we are almost going around in circles trying to define just what we mean.

Quality characteristics vary all the way from simple, obvious things that can be easily measured, such as dimensions, to things which are of a very intangible nature. Some troubles may take years to develop in the customer's home and some may be very intermittent in their occurrence. We have the problem, for example, in making refrigerators, of the quality of the porcelain in the liners, the compartment in which the food is placed. When is a porcelain inner liner a good inner liner? The number of things that we could specify to answer that question is enormous, and some of the necessary characteristics cannot be developed or revealed in any static test. It sometimes requires the dynamic nature of household use to reveal unsatisfactory conditions.

In talking recently to an apprentice class I was asked if we ever shipped a defective refrigerator. The answer to that depends upon how you define a defective refrigerator. It is possible, of course, to define a defective refrigerator in such a way that we might say all that we ship are defective, or on the other hand that none of them are defective. Certainly, by using a high powered microscope it would be possible to find some surface flaw in the finish of every refrigerator. There has never yet been a perfect surface finish produced on anything but there are such things as *acceptable* surface finishes; our objective must be to produce a finish which is serviceable, acceptable to the customer, and that will serve him well over the years.

The fourth thing which you as a consumer can do is to rate your vendors. Once a month we summarize all the results of laboratory and inspection testing by adding up the number of shipments received from each vendor and dividing that into the number of acceptable shipments. The form that we are using for that purpose (and other useful information) is in an "Information Booklet" furnished to our vendors.*

*Copy available upon request to the author.

The Vendor Rating form has been designed to provide for four years' record. The original is on 8½" x 11" paper so the form is large enough to permit the making of some notes in connection with low ratings. This is done to indicate the quality characteristic or characteristics that were troublesome for the shipments involved. These charts are brought up to date once each month and distributed through our Purchasing Department to our vendors so they know just how they stand quality wise. In addition to this they are informed within 48 hours of trouble that develops on each specific shipment.

A fifth thing that you as a vendor can do is to prepare an Information Booklet as we have done for distribution to your vendors. We strongly recommend it as a device to bring about a better relationship with your vendors. It is not intended that this booklet should be a text book on modern quality control in any sense of the word. It is intended to be only a brief explanation of what we are trying to accomplish and some of the devices we are using to accomplish those ends. Already it has brought a flood of vendors to our plant to discuss our mutual quality problems. These vendors have not previously been coming in for such discussions.

THE VENDOR'S RESPONSIBILITY FOR QUALITY

Our second main consideration is the vendor's responsibility. The vendor is the one, of course, who can actually do something about his quality. You can talk to him until you are blue in the face but unless he does something you are not going to get better quality. The quality must be built in by the vendor. To this end he should first be properly equipped to do the job that you want done. He should not attempt to produce your parts on worn out, obsolete or inadequate equipment. He should not, for example, as we found one vendor doing, try to prepare a porcelain enamel product and bake on the enamel in a situation where a lot of dust is being produced nearby. Obviously that vendor is going to have trouble getting a good finish.

Secondly, the vendor has a responsibility to test and inspect the material he ships you in the way that you will test and inspect it yourself. For only if he conducts what you

consider to be the necessary procedures to appraise quality can he be sure that he is going to send you stuff that will be acceptable to you. That does not mean that the consumer's procedures are necessarily adequate or proper, but it does mean that what is sent to him after passing such appraisals will undoubtedly be acceptable. Thus will be saved the shipping back and forth of unacceptable material or the necessity for special handling. In addition, the vendor will know sooner that something has gone wrong with his own manufacturing processes. If the vendor, in addition, will institute on his own production and assembly lines process controls that will be adequate to control quality he will find himself tremendously ahead of the game for he will know sooner than could possibly be known any other way when trouble is developing.

A third thing that the vendor should do, and is responsible for, is to certify to the consumer the results he obtains on his inspections and tests prior to shipment. You as a consumer have a right to specify the quality characteristics you need and desire and you therefore have a right to know what the vendor has found in testing and inspecting those quality characteristics prior to shipment. There is no reason why the vendor should hesitate to supply you with such information, for if the information he would supply you is something that might embarrass him, then he shouldn't send the shipment. I am happy to say that we have found our vendors uniformly cooperative in supplying us with such information.

We have a vendor certificate form which we are using for that purpose. The results of the tests and inspections by the vendor are entered in this form once or twice a week, or as is practicable under the given conditions, and mailed to us. In comparing them with our own results we have in a number of cases found discrepancies. In one case the vendor's certificates showed consistent good control and our results showed occasional serious lack of control. That contradiction provided a basis for comparing notes with our vendor, checking equipment to see if he were using the same kind of equipment we were, and to see if the equipment was operating properly. This procedure has made it possible for us to iron out a number of differences that have existed in our testing and inspection procedures.

It is our hope that ultimately our incoming testing and inspection program will become a minor issue in our plant. On some few items it has already reached that state and we are conducting only spot checks. Ultimately we anticipate that we will reach that condition on virtually all of our incoming material and when that day arrives we are going to be a lot better off and the vendor is also going to be a lot better off.

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Visit our exhibit (Booth K-5) at the National Convention. We'll have "quality" displays, training aids, and publicity suggestions.

Elliott Service Company
MOUNT VERNON, NEW YORK

Control of Visual Inspection*

ALDIS S. HAYES

Quality Control Supervisor, Perfect Circle Corporation

THE VISUAL DEFECT PROBLEM

The inspection of visual defects is similar to that of measurable characteristics in that it requires a quality standard. However, it is at this point that they part company. A quality standard for a visual defect is much more difficult to establish. In fact it is even difficult to get people to talk realistically on the subject. Once an agreement is reached, it is often next to impossible to record the decision accurately because of the infinite variety of sizes, shapes, locations, etc. Thus the necessity for some judgment is inevitable.

In order to understand the problem better let us compare an undesirable visual characteristic to a measurable characteristic. In the case of the latter it is first decided that a characteristic is needed, e.g.; the diameter of a shaft. The tolerance, or degree of variation which will be tolerated is then set and finally this tolerance is recorded on the print.

An undesirable visual characteristic, on the other hand, is not the result of planning, but occurs as the result of an imperfect process. It must first be decided if this characteristic is undesirable. The second step is to decide if all such defects—regardless of how minute they may be—shall make a piece defective (this is the tolerance), and the third step is to record the decision on the print.

Take the case of a sand hole in the side of a piston ring. Practically everyone will agree that some form of such a characteristic will cause a ring to be defective. This step is handled as easily in the case of a visual defect as it is in a measurable characteristic.

Establishing a tolerance, however, is not so simple because it must be influenced by the customer's reaction to the appearance as well as by the effect on performance. The third step, i.e., recording the decision, is not only difficult, but approaches the impossible. It may be handled by the use of some statement such as "The piece must be free of objectionable defects." Thus, the final decision is left up to a "dollar an hour" inspector because a two or three dollar an hour engineer can not describe what he wants.

Because of our inability to define a visual defect accurately, the necessity for some judgment in visual inspection is necessary. The control of this inspection will always fall short of perfection, but some control, even though it is imperfect, is better than none. It is with this thought that the Perfect Circle Corporation has approached the problem.

THE PISTON RING PROCESS

It would be well to start by explaining briefly what piston rings are and how they are made. Piston rings are essentially cast iron springs. The people who buy them expect them to:

1. Be near enough to a perfect circle so that when they are placed in a cylinder, the entire periphery will bear against the cylinder wall.
2. Meet dimensional tolerances varying from $\pm$ .00025 inches to $\pm$ .005 inches.
3. Exert a given amount of pressure when closed to operating position—as is the case with a conventional spring.
4. Be sufficiently flat to prevent blow-by.
5. Have a maximum surface finish on the sides of 25 micro-inches, root-mean-square, and in some cases one fourth of this.
6. Have a given thread contour on the bearing face—obtained by the shape of the turning tool and feed.
7. Finally, be free from "objectionable surface defects."

The manufacture of piston rings is a mass production business. Rings are made by the hundreds of thousands in several thousand sizes and types. Production rates on different machines range from several hundred rings per hour to over three hundred rings per minute. Customer inspection varies from that of the garage mechanic who has very limited inspection facilities, to engine manufacturers who have the best inspection equipment obtainable.

All of this goes into a product which is sold in a very competitive market. It is of course necessary to figure costs closely and to hold inspection to a minimum.

In our plant the visual inspection department consists of about ten inspectors who work on two shifts and are under two foremen. These two foremen report to two general foremen who in turn report to the Production Superintendent. This organization is outlined because in any inspection in which quality standards are as poorly defined as are visual standards, individual judgment plays a big part and many "on the spot" decisions are made. Thus, the more people involved, the more difficult is control.

Our visual inspection department removes about fifty percent of the total rings scrapped and until less than two years ago it was done without the aid of written or sample standards. It was this situation which led to an investigation by the Industrial Engineering Department.

INVESTIGATION OF VISUAL DEFECTS TO STANDARDIZE INSPECTION

The investigation was made on foundry defects—sand and gas holes—for the purpose of determining the variation of opinion between personnel (supervisors and engineers) and within an individual. The first step was to obtain forty rings having various sizes of defects and classify them into groups by areas. These rings were submitted to seven people to be judged as acceptable or defective, and after the rings had been inspected once by each person, they were submitted for inspection a second time.

Of the forty rings inspected, only four (ten percent) were consistently judged as acceptable or defective by the seven people. This gave us an estimate of the difference between people. Sixty-five decisions or twenty-three percent were reversed out of a possible two hundred and eighty. This provided an estimate of the consistency of judgment within a person.

*Presented at the Fourth Annual Midwest Quality Control Conference, St. Louis, Mo., November 10-11, 1949.

Thus, it was found that an extremely high degree of variation existed between people, and at least an unsatisfactory degree of variation was shown within any one person. An interesting side light was that although one-third of the decisions were to accept, all of the rings had originally been rejected by the inspection department. In other words, they had been obtained from the scrap barrel!

This experiment showed us the need for some kind of standard. Furthermore, if such a great difference existed between supervisors and engineers, it was very likely that a considerable difference existed between these people and shop inspectors. The next step then was to take a more thorough sample of the material rejected by the inspection department to determine the standard by which it was operating.

A total of eight hundred rings was selected at random from rejected material, the area of the defect measured and tallied to form a frequency distribution. It was soon found that additional classes would be needed for defects smaller than the original test sample had contained. In fact some of the rings were found to have no defects. Figuring the percent in each cell, we then calculated the annual volume and cost represented by each cell. This provided an estimate of the cost in scrap for any level which might be selected.

The next step was to test defective rings physically in order to determine at what size a defect would be critical from the standpoint of breakage. This was done by obtaining a sample of rings with various sizes of defects and putting them through three tests to determine if they were subject to breakage. From these tests it was concluded that only appearance need be considered in establishing a standard for acceptance. This standard was finally established by top management after weighing customer reaction against cost.

The next step was to get this decision to the foremen and operators in a form which would enable them to perform the inspection operation according to the standard. This was done by drilling holes of maximum acceptable size in sample rings. We knew that this was by no means a fool-proof method because of the infinite variety of shapes and sizes in which defects are found, but it at least gave us a fixed point from which judgment could operate.

The original investigation had indicated that inspection to the new standard would reduce scrap costs by $30,000 per year. This would not be brought about by a deterioration of overall quality, but rather by more consistent inspection.

With the research work completed and the final instructions given to the foremen and inspectors, we went about our other business while we waited for scrap loss to come down. A chart was kept on percent loss per day to show the improvement, but after six weeks it was evident that the desired results had not been accomplished. The stage had been set, but we did not have quality control!

PRESENT PROCEDURE

At this point a quality control inspector was assigned to the job. He sampled the outgoing or accepted material and the rejected material and published a weekly report for the foremen. Most of the errors were found to be on the side of rejected good pieces. These and the defective pieces found in accepted material were taken back to the inspectors and within four weeks, the loss had dropped to the predicted level. That happened two years ago, and a quality control inspector is still assigned to this job, because it has been found that to fix a job is not enough: it requires constant attention to keep it fixed!

As a visual aid to the inspectors and foremen, weekly charts were kept, showing both acceptable rings in rejected material and defective rings in accepted material. The former is plotted above a central line on the chart and the latter is plotted below the line. (See Figure 1) Thus a perfect performance would show only the center line, while a person who tended to be too critical would have a wide band below the center line and vice-versa. This gives the foremen an easy method for comparing operators and provides a permanent record of performance.

We do not of course expect anyone to be perfect; the ideal situation seems to be one in which the area above the line is about equal to that below the line. Most inspectors have a tendency to lean one way or the other, and the charts show this by having a broader band either above or below the center line. An inspector whose chart has a broad band on both sides is either careless or not suited to the job.

One of the by-products of this standardization of quality level has been the relative ease with which complaints can be handled. Prior to the time the standard was established, a continual state of confusion was promoted by letting customer complaints influence the inspectors and foremen. The receipt of a complaint was a cue to have inspection "tighten up", which in turn had the effect of reducing complaints. Reduced complaints was the cue to "loosen up" and the cycle started over again. Now, when a complaint is received, the returned rings are checked by the quality control department to determine whether or not they meet the standard. If they do, no mention of the complaint is made to the inspectors, and if they do not, the rings are shown to them. This has improved the morale of the inspectors, because they know what is expected of them and they can be justly praised or criticized.

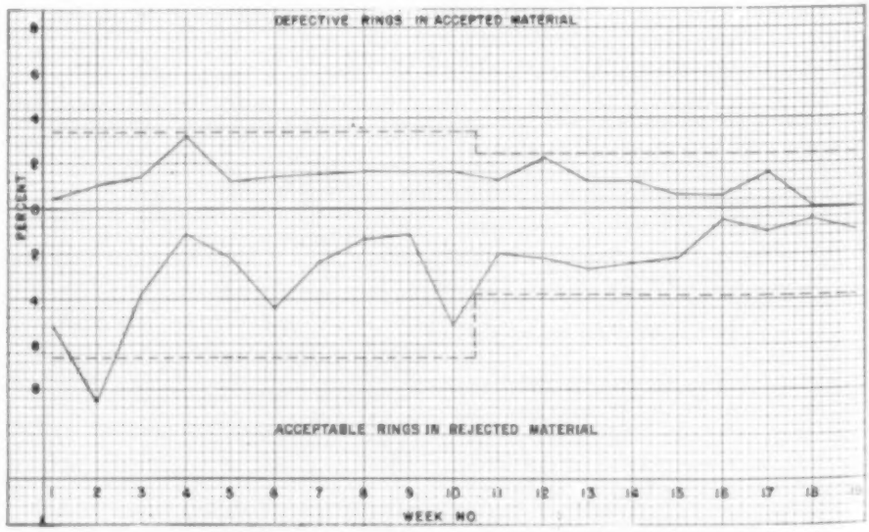

DEFECTIVE RINGS IN ACCEPTED MATERIAL
PERCENT
ACCEPTABLE RINGS IN REJECTED MATERIAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
WEEK NO

Figure 1—**Weekly Charts on Acceptable and Defective Rings**

Within one month from the time the quality control inspector was assigned to this department, scrap loss due to foundry defects was reduced by an estimated $37,000 per year. Since that time further gains have gradually been made as more was learned about other characteristics.

THE CONTROL OF INSPECTION

The control of the defects, although no easy problem to solve, is greatly simplified by the control of inspection. When a lot containing ten percent or more foundry defects is processed, the defective rings are checked by the quality control inspector and the rings then returned to the foundry with the heat date, molders clock number and pattern size. This provides factual data, and what is more important, visual evidence, as a basis for their quality control work.

The previous practice had been to return only a small sample when excessive scrap was encountered. However, it has been found that although the foundry had always been informed of the quantity rejected, a large sample has a much better psychological effect, and it is of course more representative.

In one instance the foundry scrap on rings which we made for a critical customer was about four times that experienced on other rings. This had been going on for years and the foundry had made no great effort to correct it because it assumed that the excess was entirely due to tighter inspection standards. Our work on foundry defect standards brought the loss on these rings to about three times normal, and because of our control over inspection we were able to assure the foundry personnel that the difference in loss was due to casting quality and not inspection standards. This finally brought a change in foundry practice which brought the loss down to normal.

Checking into the ability of individuals to repeat decisions has led to some startling revelations of inconsistencies in inspection. One type of ring has a lapped outside face and the specification requires that the entire face be contacted, but the tool marks must not be removed. Different lapping conditions produce different shadings on the face, and it is sometimes very difficult to determine whether or not the entire face has been lapped.

To test the validity of inspection we held a pan of rings which had been removed from a lot for relapping. Nothing whatever was done to the rings but the routing ticket was filled in as though they had been relapped. A second inspection passed sixty-seven percent of the rings. Another pan of rings was treated similarly except that in this case the inspectors were told that the rings had not been relapped. In this case forty-six percent of the rings were passed. It was finally concluded that inspectors were being critical to the point where scrap and rework costs were being increased without improving the product.

We further proved this by testing a sample of the accepted rings and one from the rejected rings. The rejected rings showed the best results. We had been misled by appearance!

One of the inspection methods to determine quality of face contact is to run rings in a motor-driven piston enclosed in a cylinder. This produces a mirror polish on the areas contacting the cylinder. The quality is then judged by the width of the polished surface, its location as to top or bottom side, and whether or not it is continuous around the rings. For a long time we were at a loss to know how to record our findings because of the number of combinations of the characteristics and the variability of degree. The problem was complicated by the fact that the test was destructive and only four rings were tested from each lot.

A solution was finally reached by judging each ring on the basis of the seven most common characteristics. A chart (See Figure 2) was made having a row for each of the seven characteristics and tallies were entered opposite each one for the number of rings having that characteristic. Each column contained the tallies for one sample of four, and after a number of samples had been entered it was a simple matter to select the characteristic which was the worst offender. Also, as time went on, trends in improvement or deterioration were apparent. We now not only have a means of detecting a failure in the process, but we have a written record of past quality.

Another phase of visual inspection which has not been overlooked is the testing of inspectors. There are several good tests available to determine a person's visual qualifications for this kind of work. The Ortho-rater is used to determine how well a person can see, while the Drake visual test evaluates a person's ability to use his eyes. In addition to this, an interest test is helpful because many people are physically equipped to do inspection work, but are not mentally suited to it. The latter is important because inspection requires a high degree of concentration and good eye sight is of no value if a person won't look. Although these tests are not perfect, they have resulted in better selection of personnel.

Finally, we have a program for checking and publishing outgoing quality on all of the major charac-

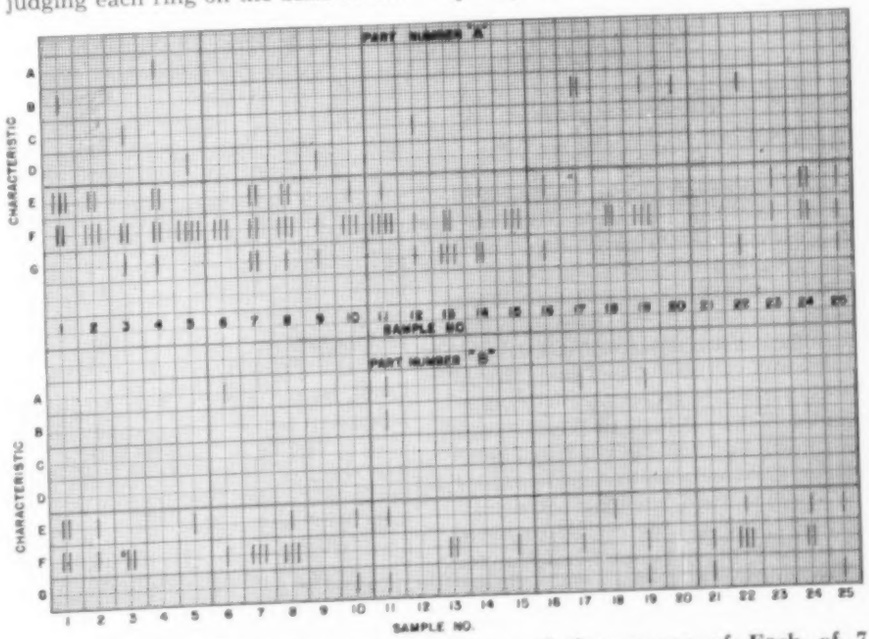


Figure 2—**Tally Chart Showing Frequency of Occurrence of Each of 7 Characteristics in Successive Samples of 4 Rings Each**

teristics and the percent of visual defects is incorporated in this report. Samples are taken from fifty random lots of finished product each week and a formal report published. It is distributed to the Sales and Engineering Departments, Plant Manager, Quality Control Department, and Inspection foremen. This not only gives us a permanent record of quality over the "long pull," but also improved customer relations.

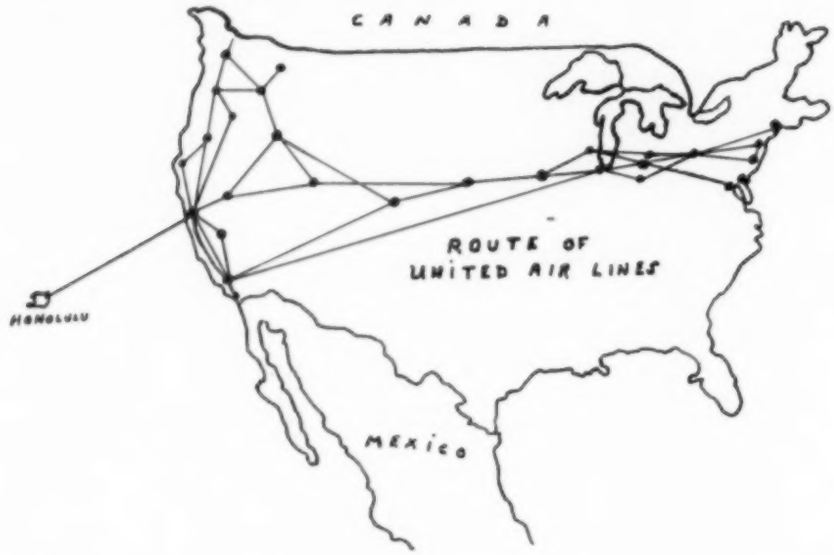
CONCLUSION

In conclusion, visual inspection is admittedly one of the most difficult kinds of inspection to control. However, any step forward, no matter how far it misses perfection, is desirable. Therefore, we do on a research basis whatever measuring is possible in order to establish the standard more intelligently; describe it in writing if possible, and at least provide samples against which the inspector can frequently check decisions. This not only reduces errors in judgment, but fixes the point from which judgment must operate. Finally, we don't expect inspectors to be perfect. They are people, and their performance will be no more consistent than the instructions which are given them. We try to make these instructions consistent by providing visual standards.

Air Transportation Finds New and Lucrative Uses for SQC*

DALE L. LOBSINGER

Staff Superintendent—Quality Control, United Air Lines, Incorporated



INTRODUCTION

The accompanying map depicts the more than 10,000 route miles of airway joining 75 important cities served by United Air Lines, Inc. The company is one of the nation's largest operators of scheduled air transportation. Hasty perusal of the map probably will suffice to impress one with the magnitude of operational and service responsibilities attending a system of such far-flung and divergent geographic limits. To be sure, the task is no small one; and, as you may surmise, it has its complications.

In the spring of 1948 this writer, a staff member for the Vice President of Passenger Service, Mr. D. F. Magarrell, was asked to concern himself with an appraisal of quality control techniques and their applicability to services which daily affect the thousands of passengers who are being transported over this vast net-work.

It is not to be assumed that this was the first time our company had become conscious of a need to provide our passengers with a good quality of service. To the contrary, United Air Lines prides itself on the enviable reputation it holds for service to air travelers. Long ago, when operations first began, the company was mindful of the importance of "taking care of the customer"; today our interest in this responsibility is reflected in a department of 1600 persons whose entire energies are bent toward assurance of efficient and comfortable travel for the patron.

Like many other service groups, our Passenger Service Department has worked diligently for satisfied customer acceptance of our product —always seeking improved techniques through which to provide the best. Like others, we have also been making the most of the job with the tools available. As years brought expansion and diversification to the operation, however, it was sometimes

*Presented at the Fourth Annual Midwest Quality Control Conference, St. Louis, Mo., November 10-11, 1949.

felt that complexities attending growth made for service responsibilities which were almost beyond our scope of control. It has been with some pleasure, accordingly, that we recognize the potentials of quality control techniques for first unraveling and then coordinating some of the more heterogeneous aspects of our work. Through control chart methods we are seeing for the first time what causes some of our processes to behave as they do, and with this added knowledge our task of correcting difficulties has become greatly simplified.

To most readers the application of SQC in laboratories, machine shops, and factories is rather a familiar story; but not so well known are the accounts of what this tool can accomplish in the non-mechanical and non-technical activities of industry. It may be of interest, accordingly, to learn how we in United Air Lines have been able to apply control chart techniques to our service functions.

Looking back over our initial efforts it is now clear that the confusion and predicament we faced differed but little from that encountered by most people making a beginning with QC tools. Our problem, we felt sure, was unique in the annals of human endeavor. In the first place, what was to be the unit of measurement for the service projects being considered, and how were we to get at it? Secondly, if the unit were to be found, what assurance was there that it would be effectively representative of the process being studied? These and a myriad other questions seemed to oppose our every move. Gradually, however, statistical perspectives began taking shape, and almost before it could be realized the control charts were doing things for us.

In service to air passengers we know that, among others, there are two particular functions which are capable of creating either a happy or a negative response on the part of customers, depending upon the skill, or lack of it, with which they are performed. These have to do with inflight meal service and the activity of booking passenger space. Let us first consider the food service.

FOOD SERVICE

To air travelers, Mainliner meals are justly famous. United Air Lines provides approximately three million annually through twelve company owned and operated kitchens and ten catering units strategically located along our routes. To the Dining Service Department the quality of the meal itself naturally is of paramount importance. In addition, however, to affording this quality in the food and assuring that the meal will be well served, there is the important responsibility for guaranteeing that the *right number* of meals—neither too many, nor too few—go aboard each flight. If there are too many, the waste costs us money. If there are too few, some passenger may go hungry; and, as you may well understand, a hungry passenger is not a happy nor a satisfied customer.

Working at the problem through the years certain idiosyncrasies became apparent in the behavior pattern of the traveling public. These included such things as failure of passengers to show up for flights without advice to the carrier, missing connections from other carriers, cancelling at the last minute, etc. This condition generally was causing us to place more meals aboard the airplanes than the actual number of passengers carried. Because, however, the condition varied from flight to flight, from day to day, from station to station, and from one type of equipment to another, the answer for correction of our losses was rather elusive. With such variables how could we eliminate the waste factor and at the same time always be sure of having a meal aboard for each passenger? The challenge specifically was that of curtailing a waste of 6½ percent which we were running on annual production.

After a start was made the answer was rather simple. Through appropriate application of $\overline{X}$ and R charts we were able to gain a factual picture of what had been happening in our food service. Once the facts became apparent, it required only the exercise of a little ingenuity to put into effect new methods of supplying meals aboard planes. The new procedures, based on evidence supplied by the charts, enabled us to reduce waste from 6.5 percent to .8 percent. At the same time we gained an almost absolute guarantee that no flight would depart *short* of food.

Since this meal condition was something, the costly aspects of which had been known for years, but which we had tried unsuccessfully to correct many, many times, it is suggested that QC treatment provided the remedy to an economic ill that might not otherwise have been handled. Moreover, since there is little evidence that the travel behavior of people will change within the foreseeable future, it would appear that annual savings, as revealed above, will continue.

Control charts on the food service are being maintained in order that we can be alert immediately to any seasonal or other form of fluctuation which might dictate a change of procedure to effect additional savings. Thus far, during the twelve months of conducting the plan, five instances have been detected in which passenger boarding patterns have so altered as to make changes in our figures desirable. The charts have become excellent watch dogs!

PAYLOAD CONTROL

As the name suggests, this Denver Operating Base function is responsible for accurate control of passenger and cargo space as sold and reported to it by our many sales offices throughout the country. The efficiency with which this control is administered has a direct bearing on the amount of revenue which the company can expect. Of equal importance, though, is the effect this office's performance can have on service to our passengers. If, for example, a person is listed on one flight or date, when he requests another, we cannot exactly expect him to send us a bouquet of roses for our actions —especially if the error ultimately results in his not having *any* space. Unfortunately, in the course of transporting about 6,000 passengers a day, errors of this sort can occur, and constant effort must be directed toward their prevention.

Eight to ten thousand reservation messages are funneled in and out of the Payload Control office each day. As they come in, posting clerks transcribe their contents to master space charts which indicate the extent to which each flight is booked. In operating some 650 flight segments per day, it is important to know that the work performed by these clerks is of the highest accuracy. Our quality control problem, accordingly, was to determine the *how* and *why*, and to what *extent* clerical errors were occurring.

We took as a unit of measurement errors revealed when comparing information found on the message with that which the clerks transcribed to the master charts. The process was complicated by the fact that some sixty employees participated in the

action; that the action carried through three different work schedules; and that there were varying degrees of work peaking from hour to hour and from day to day. With the help of a pn chart 600 messages were studied each day in subgroups of 100 strategically spaced throughout the 24 hour period. Using the first 25 samples for computation of process average and control limits, we found an error factor of 2.60 errors per sample. The errors were listed on a specially prepared data sheet, which effectively categorized them for analysis. Through use of the charts and data sheets, it was possible within one month to reduce errors in this very important activity to 1.11 per sample. At the end of a 5 month period the figure had been dropped to .47.

In view of the critical aspect of the work involved, it was most gratifying to find that SQC enabled us to reduce errors by 80 percent.

One of the most significant results of using quality control in the Payload Control function has been the establishment, in a high production *clerical* activity, of a badly needed inspection system which keeps management informed of how efficiently the work is being conducted. It makes it possible to know the extent and cost of errors.

RESERVATIONS

A third application that has brought some very worthwhile results is the one made in connection with our Reservation service—an activity which is similar in nature to the Payload Control work. Whereas, however, Payload Control is a central and sort of monitoring group, the Reservation offices center their work around specific geographic localities, making sales of space and forwarding the records thereof to Payload. It will be easily understood, accordingly, that if there is importance in minimizing errors in the Payload Control group, there is equal and possibly greater importance in making the initial booking accurate. That is to say, Payload Control could be doing and almost faultless job in keeping a record of space sold by outlying units, but if these same units were sending in inaccurate sales data, the good work of the Payload Control office would go for naught. It seemed expedient, therefore to do an error-proofing job on the field offices.

Again use was made of the pn charts with sampling in subgroups of 100. Again, too, messages containing request for space, as well as those reporting sale of same, were used as the unit of measure. Checks were made against the contents of the messages and the information transcribed from them to the reservation charts. Each office has complete records, plane by plane, of passengers it books. In addition to the name and telephone number of the passenger, the charts have such information as the number and date of the flight desired, the city of destination, whether or not the passenger is arriving via connecting carrier, continuing space if any, etc. These data, if not accurately recorded, can be the cause of reduced revenue and serious customer dissatisfaction.

Our pilot test was conducted in the Denver Reservation office. There, where total message volume runs about 1500 daily, it was found at the start of the study that there was an error factor of 10.65 errors per sample of 100 messages. Many of these could be classed as purely mechanical in nature. There was still a large portion, though, that could be viewed as very disturbing because of the adverse effect they produced on service to passengers.

Once more the data sheet played an important part. The form had to be so arranged as to clearly portray the character and extent of the errors, the critical time periods involved, and the names of the workers responsible for the major portion of the defection. Through use of SQC, performance in the Denver office showed the rather astounding improvement of 55 percent within 22 days.

CABIN SERVICE IRREGULARITIES

In closing this paper brief reference will be made to one other non-mechanical process in which control charts have been profitably employed.

For some time concern had been expressed about various irregularities that occur in the passenger cabin of the airplane. Generally these were known to the passenger before an employee of the company could learn of them; our first knowledge of the breakdown usually arrived in the form of a stewardess report explaining the annoyance which had been caused the passenger. The irregularities in question were such things as faulty reclining mechanism that caused seats to go back when the passenger wished to sit upright (or not go back when he wanted it in a reclining position); ash trays which would not pull out when needed; window curtains which would not close to keep out the light; seat belts that failed to work; etc.

Although a certain amount of inspection had always been given to detect these faulty items prior to release of planes for service, it seems that no usable form of record had ever been devised through which it could be determined just which of these little breakdowns were most repetitious and troublesome. One day, accordingly, a start was made at the New York station with a slightly different form of inspection. A c chart was used to record the results of observations. Our sample unit was the combined inspections on any three airplanes, and we managed to get one sample a day for 20 days. By the end of the first ten days it was found that irregularities and squawks were running an average of 14.1 per plane. Through systematic classification of these on a data sheet, we soon learned exactly where the trouble lay. Corrective energies were directed to the factors involved, and within the next ten-day period the average number of squawks per plane had been reduced to 7.0. It was just another example of control chart treatment giving us a simpler and more realistic perspective of a process, and with the improved form of knowledge, it was easier to find correction for troubles.

On the strength of achievements in the first test, the plan was extended to three other stations where similar benefits were experienced.

CONCLUSION

What can be listed as the most significant contribution SQC has made to our type of organization? It could probably be named as the X-ray form of analysis it provides through which we are enabled, as never before, to gain realistic perspectives and knowledge of just what our many detailed processes are doing. With such increased understanding it becomes a greatly simplified task to select the means of performing optimum service at the minimum of cost.

For our passengers—who embody the most important aspect of our business—Quality Control is making it possible for us to provide an ever-improved product of service.

Send your "Practical Aid" contribution to:
Dr. Ellis R. Ott
Rutgers University
77 Hamilton Street
New Brunswick, N. J.

Practical Aids

ELLIS R. OTT, Editor

A Chart for the Direct Reading of the Average Outgoing Quality from the Operating Characteristic Curve

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IT IS the purpose of this paper to present a graphical relationship between the operating characteristic curve of an attribute sampling plan and the average outgoing quality for that plan. An operating characteristic curve is simply a graph that shows how the probability of acceptance under the plan varies with the fraction defective in the lots presented for acceptance.

The concept of average outgoing quality (AOQ) is closely connected with that of operating characteristic, but involves the additional assumption that lots rejected by the plan are cleaned up by a screening operation that is presumed to remove all defectives in these lots. The theory behind the curves presented in this paper requires that all defectives found in samples from accepted lots, and by the screening operation on all rejected lots, shall be replaced by good pieces.

In practice, this replacement feature is not always enforced, but failure to enforce it for moderately defective lots makes relatively little difference, i.e., the AOQ values given by the curves in this paper will be closely approximated *without* replacement of defectives for lots whose quality level lies within the range commonly encountered in industry. In other words, the *replacement* of defectives is not too essential to AOQ in practice, but the screening out of defectives in rejected lots *is* essential for maintenance of the average outgoing quality levels associated with a given sampling plan.

Consider the case of a sampling plan which calls for a single sample of 100 pieces, and which allows 2 defective pieces in the sample for acceptance. From a table or chart of the summation of the Poisson exponential binomial limit, we find that if the material presented for inspection is .01 defective, then this plan has a .92 probability of accepting such lots. This means that on the average, out of every 100 lots of .01 defective quality, there will be 92 accepted and 8 rejected. If these 8 rejected lots are screened and made perfect before being re-submitted for inspection, the ultimate result will be the acceptance of 92 lots which are .01 fraction defective, and 8 lots which are perfect. The average outgoing quality is then the weighted average of the entire 100 lots, and is given by the equation

$$(1)\quad AOQ = [(92)(.01) + (8)(0)]/100 = (.92)(.01) = .0092 = .92\%.$$

If the defective pieces in rejected lots are merely removed by screening but are not replaced, the denominator in (1) is reduced to a slightly lower figure. This is so because the quantity of material finally passed into stock (theoretically) consists of the accepted lots plus the percent of the rejected lots that contains the good pieces, and this latter quantity is less than the full, original lot size. In this case, equation (1) becomes

$$(2)\quad AOQ = \frac{(92)(.01) + (8)(0)}{(92)(.01) + (8)(.99)} = .0092 = .92\%.$$

Calculations like (1) or (2) may be repeated as often as we like, using various assumed values for the presented quality. For the single sampling plan we have been considering, such calculations give the results shown in Table 1, where, for convenience, the average outgoing quality has been shown in percent rather than fraction defective. The column headed "AOQ (1)" is for screening inspection *with* replacement; that headed "AOQ (2)" is for screening inspection *without* replacement. We emphasize again that the curves on the chart accompanying this paper are based on the assumption of replacement. However, Table 1 shows

TABLE 1

Incoming Quality Fraction Defective	Probability of Acceptance	AOQ (1) (In percent)	AOQ (2) (In percent)
.000	1.000	.000	.000
.005	.986	.493	.493
.010	.920	.920	.920
.015	.809	1.213	1.216
.020	.677	1.354	1.363
.025	.544	1.360	1.376
.030	.423	1.269	1.291
.040	.238	.952	.982
.050	.125	.625	.653

(at least for a particular plan over a range of moderately fraction defective) that disregarding the requirement of replacement yields AOQ's that closely approximate those existing when replacement is enforced.

A study of these computed values of the average outgoing quality shows that they reach a maximum, and then the diluting effect of the cleaned up material which was rejected on original submission is enough to offset the poor quality of the accepted lots. This maximum has been called the "average outgoing quality limit" (AOQL).

The concept of the average outgoing quality limit is important; it means that no matter how defective the presented quality may be, the *average* quality of a large number of lots getting through the plan will not exceed this average outgoing quality limit, subject only to our proviso about screening the defective pieces out of the rejected lots.

The accompanying "Chart for Direct Reading of the AOQL from the Operating Characteristic Curve of a Sampling Plan" is presented here as a means of obviating the need for calculating the AOQ of a sampling plan by showing it directly on the chart. The method of constructing the chart will be evident from a consideration of the manner in which AOQ is computed. It will be noted from equation (1) that all we have done to determine AOQ is to multiply together two factors, one being the probability of acceptance, the other the fraction defective in the presented lots. But these two factors are simply the ordinate (y) and the abscissa (x) of a point on the operating characteristic curve, which means that all we have done is to multiply y by x.

To get the numerical value of any y by x product, it is necessary only to superimpose a grid of lines, $xy =$ constant, and assign convenient values to this constant. Furthermore, if we choose our scale factors such that the unit distance along the x-axis which equals a .01 increase in the fraction defective in presented material is the same as the unit distance along the y-axis which equals a .10 increase in the probability of acceptance, then our curve $xy =$ constant becomes a simple rectangular hyperbola. In the accompanying chart a family of such hyperbolas for values of AOQ's from .2% to 4.0% has been drawn in .2% increments. Obviously the increments could have been smaller or the range greater as desired.

To illustrate how this grid is used, the operating characteristic for the plan in Table 1 has been plotted. If we look at the point where this curve crosses the .015 fraction defective line, for example, we see that the 1.2% line of constant AOQ also passes through this point. This may be compared with the 1.213% of Table 1. (AOQ curves are given in percent to facilitate reading the chart.) We see also that where the operating characteristic curve makes its closest approach to the 1.4% AOQ line (the point marked A on the chart), it is about three-fourths of the distance from the 1.2% line to the 1.4% line, which, by interpolation, gives us an AOQ of about 1.35%. This is approximately the maximum value of the AOQ for this plan, i.e., its AOQL.

One or two comments in connection with the use of this chart are in order. First, the chart does not make any allowance for the slight improvement in outgoing quality that results from the removal of the defective pieces found in the samples from accepted lots. This is a minor error which depends on the ratio of sample size to lot size, and is on the conservative side. Secondly, it is not necessary that the scale factors be chosen on the one-to-one basis used here, but this choice does facilitate drawing the constant AOQ lines because of the relative simplicity of the rectangular hyperbola. Finally, the chart can of course be used for any type of plan: single, double, or sequential, so long as the operating characteristic is plotted.

One suggested method for using this chart is to make a transparent overlay of the hyperbola grid to place over the regular chart. Another, is to make up a master blank chart which contains the constant AOQ lines. The author has had a quantity of such charts reproduced and will be glad to furnish a reasonable number of them without charge to anyone interested in using this method of determining the AOQ and AOQL of sampling plans.

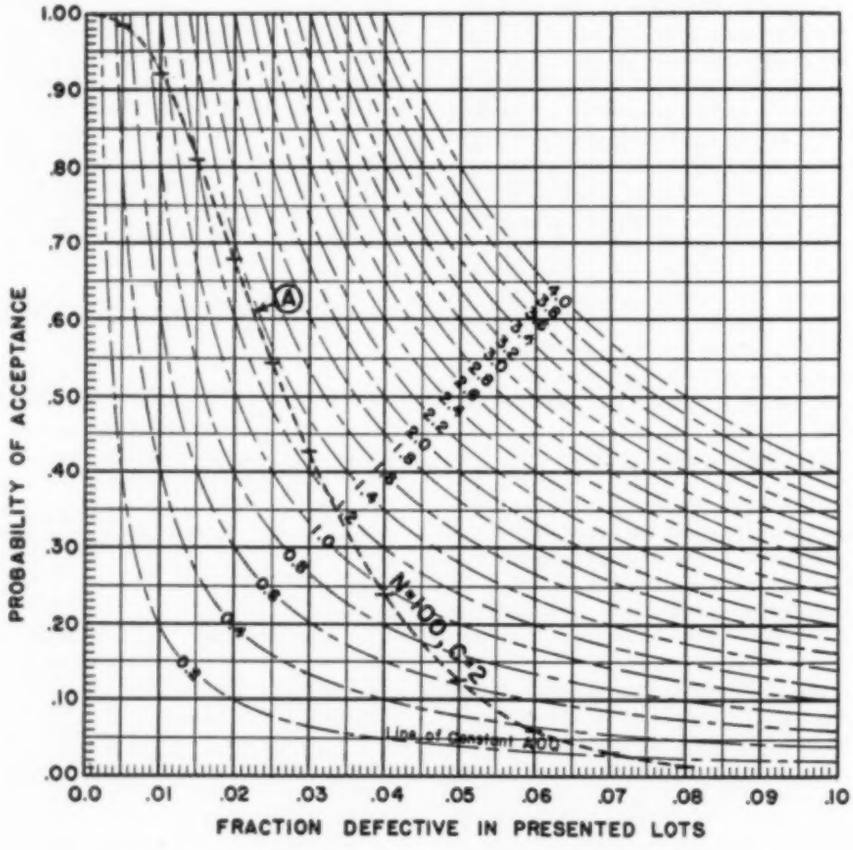
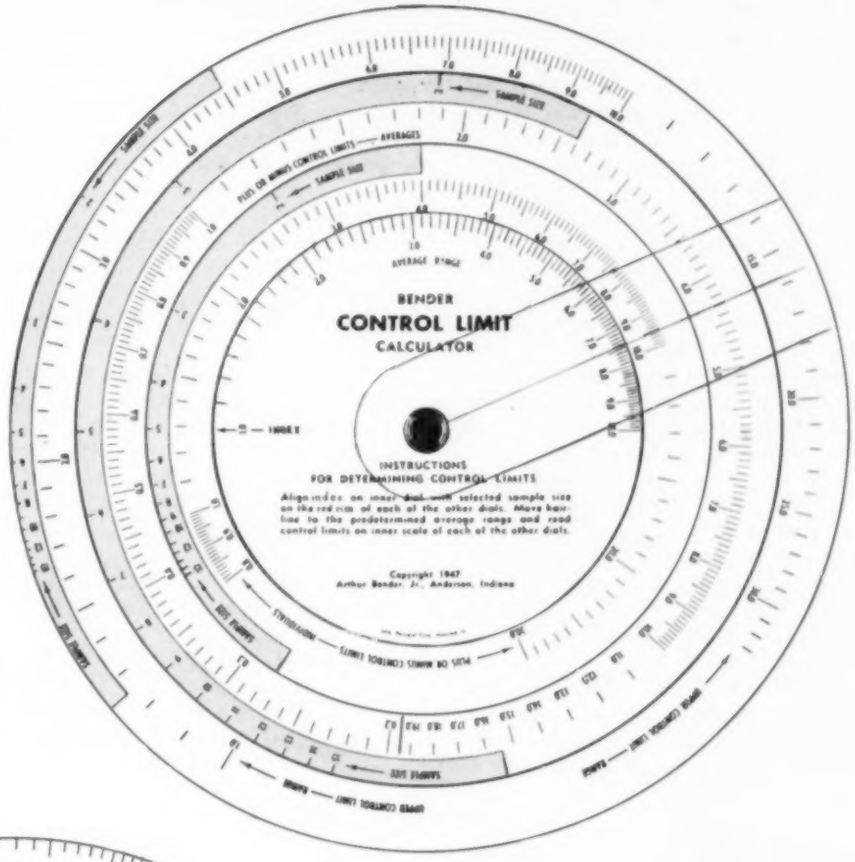


CHART FOR DIRECT READING OF THE A.O.Q.L. FROM THE OPERATING CHARACTERISTIC OF A SAMPLING PLAN

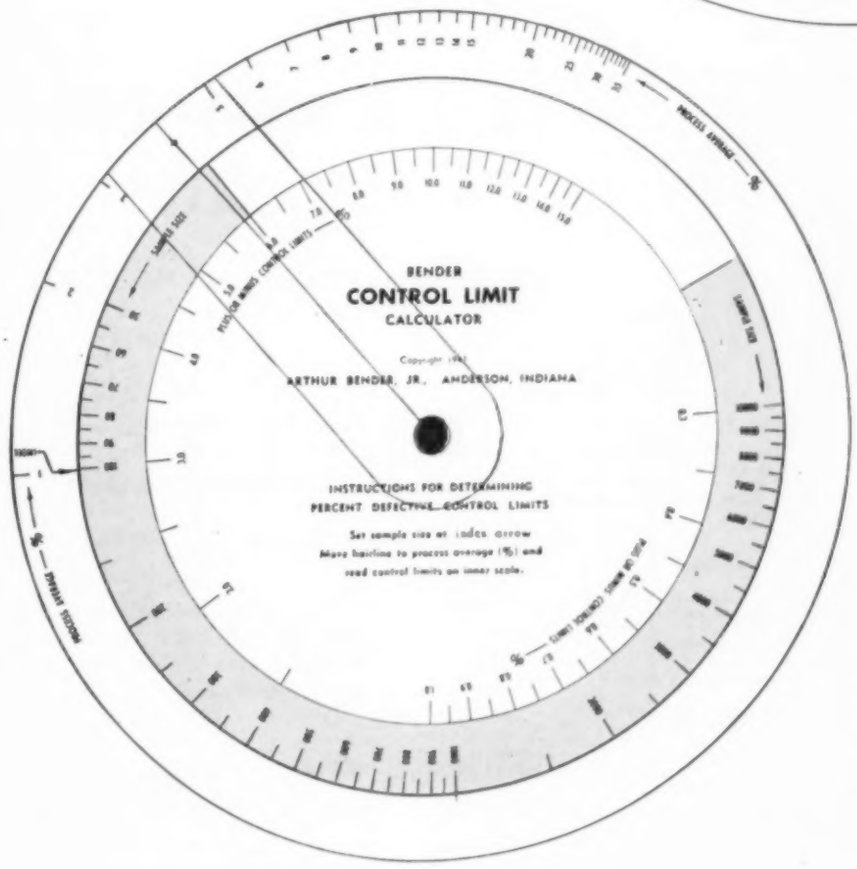
The Bender Control Limit Calculator

THE invention of the Shewhart Control Charts can unquestionably be credited with initiating "statistical quality control". These charts require the calculation and plotting of "control limits". From the point of view of arithmetic, such calculations have been reduced to a bare minimum by tables of "constants for control charts" as published in the ASTM Manuals and elsewhere.

Despite these helpful and welcome simplifications, it was inevitable that quality control personnel would seek ways to reduce the arithmetic still further by trying to mechanize it. The literature of this field contains many examples of nomographs, alignment charts, and special tables all designed to put the calculations of control chart limit lines on pretty much of a mechanical basis. As recently as July and September of 1949 this journal published contributions of this nature aimed at mechanizing these control limit calculations.


BENDER
CONTROL LIMIT
CALCULATOR
INDEX
INSTRUCTIONS
FOR DETERMINING CONTROL LIMITS
Align index on inner dial with selected sample size on the red rim of each of the other dials. Move hairline to the predetermined average range and read control limits on inner scale of each of the other dials.
Copyright 1947
Arthur Bender, Jr., Anderson, Indiana

The p-chart face (below) shows Index set for Sample Size 100 and indicator set for Process Average 4%. The Plus or Minus Control Limits are 5.9% on center line of indicator. UCL = 9.9%; LCL = 0%.



Variables-Chart face (above) shows Calculator indexed for Sample Size 5 on all Sample Size scales; indicator set at Average Range 7.4. UCL-Range = 15.7; Control Limits-Averages = $\bar{X} \pm 4.3$.

The Bender Control Limit Calculator made its advent into the quality control field at the First National Convention, ASQC, and the Second Midwest Quality Control Conference held at Chicago in June of 1947. Here at last was a device that fully and simply mechanized the calculation of control limits for individuals, averages, ranges, and fraction defective; one that eliminated completely the necessity for any auxiliary tables or charts. By appropriately setting the scales on the outer rims of concentric circular dials and giving a simple flick to a hairline indicator, control limit information becomes immediately available with a single setting of the instrument.

This Calculator, now familiar to so many quality control operators and used so widely by them, is pictured in the accompanying photographs. It is made of durable, varnished Toughcheck stock; has scales which are clearly printed in black and red colors; provides a movable, transparent plastic hairline indicator; and has all the directions needed for its use plainly and simply stated on it. It is 7½ inches in overall diameter and weighs less than 2 ounces.

In designing the scales for the Calculator, great care was exercised to secure accuracy in their construction. All scale markings on the variables-chart face are consistently one unit apart; those on the p-chart face show half-units on the control limits and sample-size scales. Furthermore, on the variables-chart face, once the decimal point location has been chosen for average range, its position is preserved automatically on all other related readings.

Other more elaborate instruments for control chart calculations can be designed, and some are now coming on the market, as would be expected, but the Bender Control Limit Calculator holds the distinction of being the first designed exclusively to fully mechanize control limit calculations on both variables and attribute charts. Its low cost, simplicity, ease of operation, durability, and practical usefulness are features that mark it as a leader and worthy competitor in its field.

Orders for the Calculator have furnished a revealing insight into the way industrial interest in quality control grows. These sales records trace very clearly a pattern that shows how the movement spreads first through individual companies and their branches and then through companies in a related field of industry.

Although designed initially to simplify calculations, the instrument has proved to be of even greater value as a teaching aid, particularly for in-plant training programs. The complete absence of any formulas or technical nomenclature has a strong appeal to shop personnel who are traditionally wary of any approach that appears to involve mathematical complications.

The Bender Control Limit Calculator is available through its originator, Mr. Arthur Bender, Jr. (Indianapolis Section, ASQC), at Anderson, Indiana, and is advertised elsewhere (p. 86) in this issue. Mr. Bender is Quality Engineer for the Delco-Remy Division of General Motors Corp.

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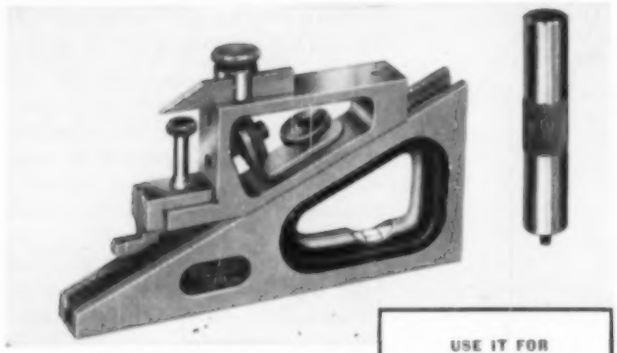

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Bibliography

JOSEPH MOVSHIN, Editor

Assisted by the Editorial Committee, St. Louis Section, ASQC

On matters concerning the Bibliography Department, send correspondence, suggestions, and contributions to: Mr. Joseph Movshin, 9220 Old Bonhomme Road, St. Louis 24, Mo.

APPLICATION—CHEMICAL INDUSTRY

DEVELOPING A CALENDERGRAPH
(The Application of Modern Quality Control to the Calendering Process)
Anthony Oladko, Production Superintendent, Johnson & Johnson, New Brunswick, N. J.
(The Rubber Age, v. 65, n. 6, Sept. 1949)

This article presents a description of the problems of control of a calendering process, and particularly the use of the $\overline{X}$ and R chart as a solution to some of these problems. Process capability, through quality control analysis, becomes a known factor for inspection, engineering, and laboratory personnel to work from, rather than an unknown factor.

AN EMPIRICAL TREATMENT OF VISCOSITY DATA AND ITS APPLICATION TO QUALITY CONTROL IN THE GLASS INDUSTRY, James P. Poole, Pennsylvania State College
(The Glass Industry, v. 30, n. 1, Jan. 1949)

Correlation is used to establish a control for glass making. A function of viscosity and temperature is used to control the glass composition.

APPLICATION—ELECTRICAL INDUSTRY

SIMPLIFYING QUALITY CONTROL, F. H. Wells, Director of Research, Aircraft-Marine Products Inc.
(Electrical Manufacturing, v. 43, n. 4, April 1949)

Probability paper is used to analyze collected data for process and design characteristics. This use of probability paper, and the analysis of the data therefrom, may be made without special knowledge or training in statistics. The application illustrated is to the pull-out strength of insulated pin terminals of two different lots.

APPLICATION—FOOD INDUSTRY

LET STATISTICAL QUALITY CONTROL CUT YOUR COST, Frank Kenney, Quality Control Laboratory, White Rock Corp., Brooklyn, N. Y.
(Food Industry, v. 21, n. 11, Nov. 1949)

Quality control is introduced as a technique to avoid guess work in the production of bottled beverages. Cost savings in production, as well as an aid to research and other industrial functions are presented as benefits from the use of quality control.

APPLICATION—METALLURGICAL INDUSTRY

PRODUCTION CLINIC FOR FINISHING DIE CASTINGS, Report of an address by Dr. Russel E. Harr, Western Electric Corp.
(Die Casting, v. 7, n. 12, Dec. 1949)

The $\overline{X}$-R chart is used in an unusual way to regulate the thickness of plating as measured by a magnetic flux method. Median and minimum values are used on the chart. Warning is given of the danger of a series of non-random samples, such as trends, etc.

APPLICATION—MISCELLANEOUS

EXACT QUALITY CONTROL, Waldo W. Higgins, Chief Engineer, A. O. Smith Corporation
(Ceramic Industry, v. 52, n. 5, May, 1949)

The use of a demerit system for inspection and quality control of water heaters is discussed by Mr. Higgins. The ratings are plotted on a regular $\overline{X}$ chart, and this chart average becomes a measure of an outgoing quality level. This approach considers not only the number of defects found, but the seriousness of each, in evaluating product quality.

BENEFITS FROM QUALITY CONTROL, S. Collier, Director of Quality Control, Johns-Manville Corporation, N. Y.
(Purchasing, v. 26, n. 1, Jan., 1949)

Quality control has value and application to the field of the purchasing agent. Some of the general benefits and use of quality control to the purchasing agent are briefly presented.

STATISTICAL METHODS DOUBLE QUALITY CONTROL EFFICIENCY, S. E. Peters, Chief Inspector, The Dumore Co., Racine, Wis.
(Factory Management & Maintenance, v. 107, n. 3, March, 1949)

An account of improvement in quality and saving in costs following the introduction of statistical methods at the Dumore Co. Illustrated with control charts and frequency distribution charts.

ENGINEERING & EXPERIMENTS

THE STATISTICAL PART IN WELDING INVESTIGATION, B. B. Day, U. S. Naval Engineering Experiment Station, Annapolis, Md.
(Welding Journal, v. 28, n. 10, October, 1949)

Variability and uncertainty are always present in the design of welding investigations as well as in all experimental work. The use of statistical techniques to help control and measure the effects of this variation and uncertainty is discussed in this article. The design and evaluation of a typical welding investigation is presented.

THE USE OF STATISTICAL METHODS IN DETERMINING PRODUCT SPECIFICATION, Charles A. Bicking
(Tappi, v. 32, n. 9, September, 1949)

Various quality control methods (control chart etc.) may be used to set specifications that are "natural" for the process. An example of such a specification is given. Provision for the review of specifications is made.

STATISTICAL ANALYSIS OF EXPERIMENTAL DATA, E. Rossow
(Aircraft Engineering, v. 21, n. 250, December, 1949)

Mr. Rossow discusses in a very technical manner some of the problems and fallacies involved in the analysis of non-normal distributions by plotting the ogive or summation curve on probability paper. The problem of analysis of mixed distributions is also considered in this paper.

THE STATISTICAL ANALYSIS OF EXPERIMENTAL DATA, B. Saravanos, A.F.R. Ae. S.
(Aircraft Engineering, v. 21, n. 241, March, 1949)

This is a highly technical article on a graphical method of investigating non-normal frequency distributions. Summation frequency curves for various distributions are plotted on probability paper and analyzed mathematically to determine the nature of the universe on the basis of limited data.

MANAGEMENT & PERSONNEL

GETTING EMPLOYEE COOPERATION FOR QUALITY PRODUCTION, From "Stimulating Employees' Interest in Quality Production", The Darnell Corp., Chicago
(Management Review, v. 38, n. 11, November, 1949)

Management must institute the necessary steps to obtain employee interest in quality production. Several approaches to the problem of creating quality minded employees are mentioned.

APPLICATION OF STATISTICS TO THE SCIENCE OF MANAGEMENT, Dr. J. M. Juran, New York University
(Mechanical Engineering, v. 71, n. 4, April, 1949)

The need and general application of the "scientific method" to industrial management is discussed. Statistical Quality Control as the scientific method in quality control is presented as a most useful management tool. The "selling" of quality control is also discussed. While the actual use of statistics is not shown, some few general type applications and results to be expected are noted.

MISCELLANEOUS

STATISTICAL METHODS & QUALITY CONTROL, L. C. Young, MIT
(Mechanical Engineering, v. 71, n. 11, November 11, 1949)

A review of the books "Statistical Methods in Research" by Palmer O. Johnson, and "Quality Control in Industry" by John C. Rutheford.

The author presents a general outline, with comments, of the material contained in the two texts reviewed.

NEEDED—SPECIFIC SPECIFICATION, Earle Buckingham, MIT

TROUBLE SHOOTING WITH QUALITY CONTROL, E. E. Schiesel, Stevens Institute of Technology

HOW TO BOOST QUALITY, Dr. J. M. Juran, Department of Administrative Engineering, New York University
(Machine Design, v. 21, n. 12, December, 1949)

The December 1949 Machine Design has a series of abstracts of various papers presented at various meetings. Among these are abstracts of the above three papers which were presented at the Third Annual Convention of the ASQC.

THEORY & APPLICATION—GENERAL

QUALITY GUARANTEED, Louis N. Sarbach
(Forbes Magazine of Business, v. 63, n. 4, February 15, 1949)

A very non-technical review of the use and methods of Statistical Quality Control. Worth while savings in various companies are noted.

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Hunter Spring Co., Lansdale, Pa., Sept. 1949
(Steel, v. 124, n. 2, January 10, 1949)

Short summary of the use of quality control as an aid to inspection and design engineering.

THE GOLD MINE IN QUALITY CONTROL, C. W. Kennedy, Chairman, Publicity Committee, ASQC
(Purchasing, v. 26, n. 6, June, 1949)

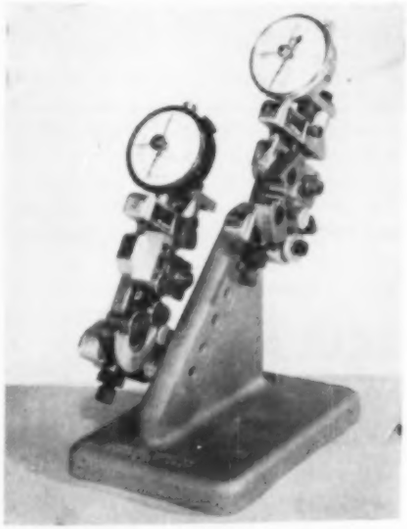
Quality control is presented as a cost saving, production increasing, and quality improving tool for modern industry.

SETTING UP A STATISTICAL QUALITY CONTROL PROGRAM, Lester F. Spencer, Landers Frary & Clark
(Tool Design, v. 23, n. 3, September, 1949)

Covers frequency distributions, $\bar{X}$ & R charts, sampling plans, applications to purchasing and receiving inspection as well as production process. A number of charts are shown and a short list of references given.

QUALITY CONTROL OF LIMITED PRODUCTION, C. D. Wright, Chief Engineer, Reliable Toy Co., Ltd.
(The Tool Engineer, v. XXIII, n. 6, December, 1949)

Part 3 of a Panel Discussion on Limited Production. A general review of the factors influencing cost of quality and affecting product quality.



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BASIC QUALITY CONTROL COURSE

University of Colorado
Boulder, Colorado, August 14-25

A ten-day intensive training course in Quality Control by Statistical Methods will be offered by the College of Engineering (including the Departments of Applied Mathematics and Mechanical Engineering) at the University of Colorado, Boulder, Colorado, August 14-15, 1950. Staff for this course will include Dr. Lloyd Knowler of the State University of Iowa, Dr. Mason Westcott of Northwestern University and Professor John Henry of the University of Illinois, as well as additional faculty members from the Colorado area and representatives from industry.

Instruction will follow, in general, the pattern laid down in previous courses of this type. Basic control charts and sampling techniques will be emphasized along with brief descriptions of other statistical techniques useful to industry and business. Some knowledge of algebra and statistics will be useful but not essential. The course will be intensive, mathematically non-technical, and practical.

Tuition will be $100.00 per person for the ten-day period and later follow-up, and will include all books and supplies. Accommodations will be available in modern University housing facilities for rates from $23-$32 per week, including meals, or rooms and cabins may be obtained in hotels and tourist camps off the campus at considerably higher rates. Further inquiries and applications for enrollment should be addressed to Professor A. R. Deschere, Department of Mechanical Engineering, University of Colorado, Boulder, Colorado.

MICHIGAN QUALITY CONTROL COURSE

The University of Michigan will offer a ten-day course in Statistical Quality Control August 21-31, inclusive on the campus in Ann Arbor. This will be a repetition of the successful introductory course given in August in 1948 and 1949. It will be intensive, mathematically non-technical, and practical.

Professor C. C. Craig will be in charge, and the staff will include Professors I. W. Burr of Purdue University and E. G. Olds of Carnegie Institute of Technology and Mr. E. C. Yehle of the University of Michigan. The registration fee of $100 per person includes a textbook and a syllabus of the course.

For further information write to Professor C. C. Craig, 106 Rackham Building, University of Michigan, Ann Arbor, Michigan.

ADVANCED COURSE IN STATISTICAL QUALITY CONTROL — PURDUE UNIVERSITY

An eight-day advanced course in statistical quality control will be offered by Purdue University Sept. 8-16 inclusive. This course is intended to meet the needs for additional training of men and women who have had some previous instruction or practical experience in the subject.

Topics to be offered are: review and background of control charts, significance of differences, principles of acceptance sampling, sequential analysis, both attributes and measurements, linear and multiple correlation, analysis of variance, tolerances of fitting parts, chi-square, and use of calculating machines.

Prerequisites are a first course or its equivalent. The emphasis will be on applications, and all techniques will be explained as simply as possible.

Tuition is $100. For additional information, write to Professor Irving W. Burr, Department of Mathematics, Purdue University, Lafayette, Indiana.

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After the Dializer is installed it is easily adjusted by means of a knurled nut. It may be clamped in final position by the same locking mechanism used originally for one of the gaging pins. After conversion, the gage will have the same range of adjustment as it did before.

At present the Dializer is available from the manufacturer, Standard Gage Company, Inc., Poughkeepsie, N. Y.

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Book Reviews

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University of Georgia
Athens, Ga.

THE SCIENCE OF CHANCE: FROM PROBABILITY TO STATISTICS

H. C. Levinson. Rinehart & Co., New York, 1950. 348 + vii pp. Paper. $2.00. Review by Paul Peach, Associate Professor, Department of Experimental Statistics, North Carolina State College, Raleigh, N. C.

This book is a revision of the author's earlier work "Your Chance to Win" and is in fact the same book, with some new material added to bring in, for example, illustrations from World War II. I have often recommended the older work as collateral reading for students in statistics, and am very happy that it is once more available.

The book is divided into two parts, called "Chance" and "Statistics." The first part, just over half the book, is a popular exposition of probability. It does not present proofs of theorems, but instead introduces many of the basic concepts by showing their applications to games of chance, stock market speculation, and the like, with some comments on the relation of chance to superstition. The discussion of draw poker is the best I have ever seen, and incidentally corrects some errors of other publications. System play in roulette is described with enough detail so that any bright reader should be able to invent his own systems. There is also a perfectly correct explanation of why all these systems are sure to produce, in the long run, a profit for the bank; somehow I feel that the argument is a little unconvincing, and would leave me still doubtful if I were a system player. The first part of the book concludes with a section on lotteries, craps, and bridge.

All this is presented in an easy humorous style which I consider the best kind of expository writing. I'm sure there will be many students who, once started on page 1, will be unable to lay the book down until they reach page 198, where the first part ends. I have really only one adverse criticism. Dr. Levinson says (with other authorities) that the probability of an event depends upon the amount of our information, and changes when our information increases. In recent years a somewhat different point of view has gained favor: that the probability of an event is as definite a quantity as the length of a board, and that increasing information does not alter that quantity at all, though of course it may affect our measurement or estimate of its magnitude. I prefer this point of view.

Levinson's subjective view of probability has very little effect on the first half of his book, but makes quite a difference in the second, on "Statistics". An objective approach to probability leads naturally to the distinction between "parameter" (the unknown true value which we seek to measure) and "statistic" (the number to which our process of measurement or estimation leads). This distinction is quite essential to modern statistical thinking, but it plays at most a minor part in Levinson's discussion of statistics, and enters mainly by inference only. To my mind the section on "Statistics" is inferior to the one on "Chance"; the examples are not especially stimulating, and the development ignores most of the exciting advances made in applied statistics since, say, 1924. Some recent books are mentioned by title.

I quote from page 218: "Statistics are tables of past facts . . . The science of statistics thus consists of three indispensable parts: collecting the data, arranging them in the form of statistical tables, and, finally, utilizing and interpreting these tables." As a statistician, I protest. It seems to me we might as well define literature by saying "The production of a literary work proceeds in three steps. First, we must learn the letters of the alphabet. Second, we must master the art of assembling the letters into words, words into sentences, and sentences into paragraphs. Finally, we must prepare a collection of paragraphs which taken as a whole shall have artistic merit." Dr. Levinson's definition places the clerical details of enumeration and tabulation on the same footing as the difficult problem of uncertain inference, and neglects, it seems to me, the most dramatic and inspiring advances of statistics, which ought to be his main exhibit.

His use of statistical terminology will give some students trouble. Thus, when he says "significant" he doesn't at all mean what is meant by the modern writers he mentions—R. A. Fisher, Wilks, Hoel, Cramer et al. He devotes right much space to "probable error", a quantity which I (among others) would like to see decently interred. On the other hand, the worst we can say here is that Levinson uses, for the expression of some of his ideas, a somewhat obsolescent vocabulary. The ideas themselves are sound enough. For instance, on page 258 we find what looks like a statement that it is a waste of time to calculate an average unless the measurements show "small dispersion". Naturally, Levinson does not mean that we should calculate averages only when the variance is quite small; he means that an average has no clear interpretation unless it is based on a sample from a statistically homogeneous population. The idea is certainly valid, and deserves all the emphasis we can give it.

This may all sound like a roast of the section on "Statistics" but I don't mean it that way, and I should be sorry to conclude this review on a sour note. The sections on applications of statistics to advertising and business are interesting and valuable. The pleasant, readable style and the obvious common sense which permeates the book more than offset what I regard as defects of treatment. I am sorry for the paper binding; the book deserves hard covers. Its informality assures that some students will actually read it, a mark of esteem not commonly accorded to text books.

Of course, "The Science of Chance" does not pretend to be a text book and cannot take the place of one. I still regard it as excellent supplementary material. I shall caution my own students against Dr. Levinson's occasional paleologisms, and tell them to read the book with the expectation of both enjoyment and profit. If you are a teacher of statistics, my advice is "Go thou and do likewise."

AMERICAN SOCIETY NEWS

HAROLD F. DODGE TO BE AWARDED THE SHEWHART MEDAL

The Shewhart Medal Committee has announced that Mr. Harold F. Dodge of the Bell Telephone Laboratories, New York City, has been unanimously selected as the Shewhart Medallist for 1949. The ceremony of medal presentation and Mr. Dodge's address will be the highlights of the Society's Annual Dinner Meeting at Milwaukee on June 1.

Mr. Dodge is a Fellow of the Society, a member of the Society's Editorial Board, and Chairman of the ASQC Standards Committee. Prior to his joining the Western Electric Company in 1917, Mr. Dodge was an instructor at Massachusetts Institute of Technology. From 1925 to date, he has served as Quality Results Engineer of the Bell Telephone Laboratories. During the recent war, Mr. Dodge served with distinction as Consultant to the Secretary of War on Quality Control and Sampling Procedures.

Mr. Philip L. Alger of General Electric Company, Schenectady, is Chairman of the Shewhart Medal Committee and will take part in the Milwaukee ceremonies.

SHEWHART MEDAL COMMITTEE

Professor Irwin S. Hoffer of Temple University, Philadelphia, has requested that the Society accept his resignation as a member of the Shewhart Medal Committee, due to considerations of health following his recent illness. The Executive Committee has reluctantly accepted his resignation and has voted its thanks to Professor Hoffer for his work on the Committee since its formation. The President has sent to Professor Hoffer the best wishes of the Society for his continued recovery.

Mr. J. F. Verigan, National Director of the Ohio Section, has been appointed to serve the balance of Professor Hoffer's term to June 30, 1951.

1949 BRUMBAUGH AWARD

Mr. Halsey H. Kent, Chairman of the Brumbaugh Award Committee, has announced that the first winner of the Brumbaugh Award will be Mr. Leonard A. Seder of the Gillette Safety Razor Company in Boston. Mr. Seder's article on "The Technique of Experimenting in the Factory" was published in the March 1948 issue of Industrial Quality Control; this paper was judged by the Brumbaugh Award Committee to have made "the greatest contribution to the development of industrial applications of quality control" among all papers published in the first five volumes of the magazine.

The first Brumbaugh Award of $50 will be given to Mr. Seder at the Annual Dinner Meeting of the Society in Milwaukee on June 1.

MIDWEST SECTIONS MAKE SUSTAINING CONTRIBUTION

The Midwest Sections have presented the Society with a Sustaining Contribution of $500 from the proceeds of the Fourth Midwest Quality Control Conference held in St. Louis on November 10 and 11, 1949. This generous contribution supplements similar gifts from the preceding Midwest conferences and brings to a total of $2500 the amount of such gifts.

In making this contribution, the Midwest Sections also sent their "best wishes for the continued success of the American Society".

The Executive Committee has expressed its appreciation for this further generous support of the Society and its program.

EXECUTIVE COMMITTEE MEETS

The Executive Committee of the Society held a highly successful two-day meeting on Saturday and Sunday, February 18 and 19, at the Johns-Manville offices in New York City. All but one of the twelve members of the Executive Committee was present.

The Executive Secretary presented a report on Society membership as of February 9, showing a total membership of 2793 of whom 72 were Fellows, 1069 were Senior Members, and 1638 were Members. In addition to these, 153 more memberships were received up to meeting time—bringing total Society membership as of February 18 to 2946. The Executive Secretary pointed out that 938 new members have joined the Society this year but that 784 members last year have failed to renew their memberships.

The Treasurer presented a report showing Society funds on hand in the current account amounting to $10,781.87 as of February 1, 1950. Income received during the first seven months of the current year totalled $18,700.25 and disbursements during the same period amounted to $10,-382.88. The budget for current year operations was reviewed in the light of operating figures.

Dr. Mason E. Wescott, Chairman of the Editorial Board, announced that arrangements have been made with Cuneo Press in Milwaukee to publish the 32-page March issue. Dr. Wescott also reported that all previous business arrangements for publication of the magazine have been terminated. Plans are under way for putting into effect the recommendations of Vice President Weaver's committee which are designed to lighten the load of work on the Editorial Chairman and to strengthen the work of the Board.

Mr. Raymond S. Saddoris, General Chairman of the Milwaukee Convention, reported on plans for the Convention and for making the May issue of Industrial Quality Control the Convention number. Mr. Saddoris and Mr. F. J. Halton outlined plans for securing special advertising for this issue and requested and received support of the Board of Directors in carrying through this program.

The Executive Committee decided that its next meeting will be held on Wednesday afternoon, May 31, in Milwaukee. The Annual Corporate Meeting of the Society will be held at 4:30 p.m. on Thursday, June 1, in Milwaukee. On Saturday, June 3, the Board of Directors will meet.

Each Regional Director reported on Society activities in his region and on the desires of his region regarding operating procedures, membership renewals, membership inquiries, and membership cards. On the basis of these reports, a plan was adopted for simplifying the membership work of the national office.

The Executive Committee designated Messrs. Collier and Shainin to work together in preparation of the 1950-51 dues billing form and billing procedures.

The Executive Committee designated Messrs. Bates and Halton to work on the revised membership information folder and to have final recommendations ready before August 1.

It was decided to form a special committee composed of Messrs.

Charles J. Hudson (Chairman), Robert S. Inglis, Leonard A. Seder, Dorian Shainin, George W. McDermott, and Simon Collier to:

(a) Draft a set of procedures for efficient handling of Sub-Sections of Society Sections, and
(b) Prepare a model constitution that may be used as a guide by Sections in preparing their constitutions.

Vice President Weaver reported on plans for the 1951 Convention in Cleveland and that Dr. Martin A. Brumbaugh will serve as program chairman of the convention.

As a result of recent requests by individual Sections for transfer from one Region of the Society to another Region, a special committee was appointed consisting of the Vice President and all Regional Directors to consider present geographical divisions of the Sections and to recommend to the Executive Committee any desirable changes.

The Executive Committee devoted considerable discussion to the matter of dues structure, date of annual meeting, balloting at annual meeting, and procedures for constitutional amendments. As a result of this discussion, decision was made to submit several amendments to vote of the membership at the coming annual meeting in Milwaukee.

Numerous other matters were given detailed consideration at the meeting and action taken in connection with a number of them is reported elsewhere in this issue of the magazine.

SOCIETY MEMBERSHIP BADGES

At its last meeting, the Executive Committee adopted Society membership badges for each grade of membership. These badges follow the contour and design of the official insignia, with a half-inch diameter and a blue center field; they are available as follows:

Grade of Membership	*Badge*	*Cost*
Member	Sterling Silver	$1.75
Senior Member	10K Gold	3.75
Fellow	10K Gold with Sapphire	4.75
Honorary Member	10K Gold with Diamond	...

All of the above prices include Federal Excise Taxes.

The badges are to be manufactured by the L. G. Balfour Company and may be ordered by Section Secretaries from the office of the Executive Secretary. A supply of badges for each membership grade will be available at the Society booth at the Milwaukee Convention.

CHARLES J. HUDSON BECOMES ASSISTANT EXECUTIVE SECRETARY

Mr. Charles J. Hudson of the Norton Company, Worchester, Massachusetts, has accepted appointment as Assistant Executive Secretary of the Society. Mr. Hudson was a member of ASQC's first Executive Committe, serving as New England Regional Director; he is also Chairman of the Committee on Professional Ethics and Qualifications.

Mr. Hudson will assist the Executive Secretary, primarily on special assignments, so as to assume part of the load now carried by the Executive Secretary.

SOCIETY TRAINING MANUAL

At its meeting in New York on February 18-19, the Executive Committee unanimously accepted the proposal of the Midwest Sections that their Training Manual be turned over to the American Society and developed as a national training publication. This transfer has now been made and copies of the present Training Manual are available from Mr. A. L. Davis, national Treasurer, at the following prices:

1 to 25 copies ..... $.50 each
26 to 50 copies ..... .40 each
51 copies and up ..... .25 each

President Wareham has asked Professors Niles Barnard and John A. Henry to assume responsibility for review of the present training manual with a view to improving and modifying it as may be desirable. When this work has been completed, a revised training manual will be published by the Society.

A letter of appreciation has been sent to the Midwest Sections and also to Professors Barnard and Henry who developed the present training manual.

ASSISTANCE TO PROGRAM COMMITTEES

Mr. John G. Rutherford, Chairman of the Program and Speakers Committee, has announced that his committee has prepared a listing of quality control speakers segregated by the Region of the Society in which the speaker lives. This report is available to all Section program committees for use in preparing their 1950-51 programs.

Copies of the report may be secured directly from Mr. John G. Rutherford at the Glenn L. Martin Company, in Baltimore, Maryland.

Mr. Paul A. Robert of IBM is Vice-Chairman of this Committee.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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POSITION WANTED

QUALITY CONTROL ENGINEER desires responsible position. 5 years experience in installing sampling plans and placing controls on manufacturing and assembly processes in mechanical and chemical industry. B.S. in Engineering. Age 30. Family. 10 years in diversified engineering lines. Able to deal with management and labor in quality correlation of production, engineering, inspection and sales. Senior Member of ASQC. Reply to 6F1, American Society for Quality Control, 22 East 40th St., New York 16, N. Y.

MECHANICAL ENGINEER, 27, BSME 1948; 18 months pattern shop, foundry, welding, and machine shop practice; 9 months tool engineering; 10 months quality control engineer. Member ASQC. Desires position in production or management fields. Reply to 6F2, ASQC, 22 E. 40th Str., New York 16, N. Y.

QUALITY CONTROL ENGINEER desires position organizing and supervising quality control installation. Experienced in organizing, supervising, and instructing. Background: B.S.-M.E., Quality Control, Methods, Time Study, Machine Operation. Reply to 6F3, ASQC, 22 E. 40th St., New York 16, N. Y.

QUALITY CONTROL at BURGESS

Is Your Assurance of Uniform Dry Battery Operation!

A Quality Dry Battery For Every Purpose

Yes—quality of product has been the guiding factor for more than forty years in the manufacture of Burgess Batteries. Burgess engineers first began the use of quality control methods 15 years ago to assure the user uniform high quality batteries. Today, quality control at Burgess is employed from incoming raw materials to the final test of assembled batteries. That's why two out of three electronic engineers today specify BURGESS; that's why BURGESS Batteries have been first choice of scientists and explorers.

Burgess has devoted more than 30 years to the production of batteries for special and industrial applications. Hundreds of types are available to industry through local Burgess distributors. Write to Burgess Battery Company for a catalog of descriptive information to assist you in ordering Burgess Batteries locally.

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If you are designing a new battery-operated product and need a special battery, Burgess engineers will assist you in providing the correct battery. Handy check-sheet enables you to describe your exact requirements. Write for one today.

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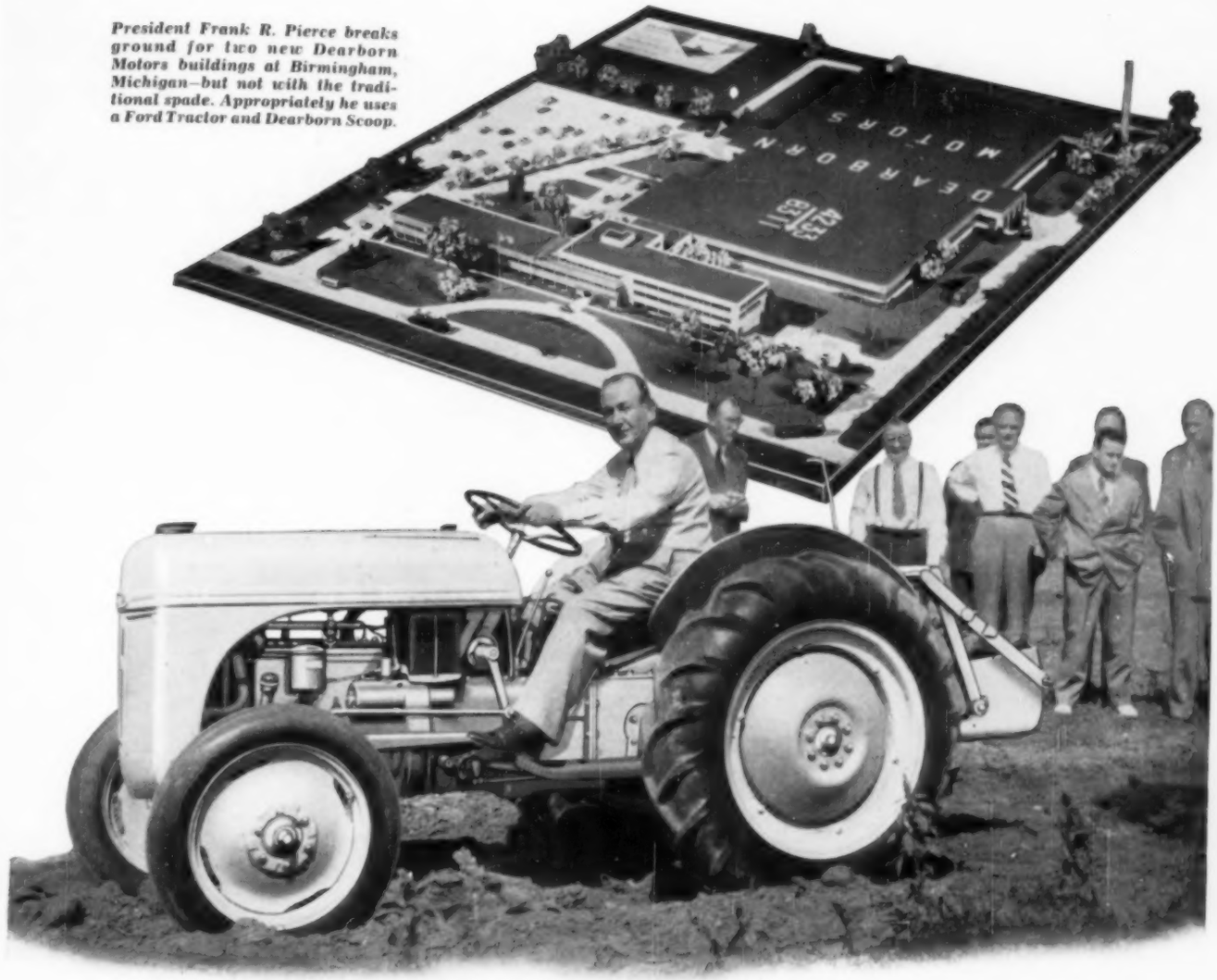

President Frank R. Pierce breaks ground for two new Dearborn Motors buildings at Birmingham, Michigan—but not with the traditional spade. Appropriately he uses a Ford Tractor and Dearborn Scoop.

for Greater Service to Agriculture

The first two units of a multi-million dollar expansion, engineering and research program by Dearborn Motors are now under way. Costing in themselves three million dollars, the buildings now under construction will provide a complete modern research laboratory, a huge parts warehouse and the company's general offices.

The continuing research activity of Dearborn Motors, in the laboratory and in field testing throughout the country, has already produced important advances in design, quality control and precision manufacture of farm machinery. Completion of new and expanded research facilities will permit this work to go forward at an accelerated rate.

Ford TRACTOR

DEARBORN MOTORS CORPORATION
DETROIT 3, MICHIGAN
"A Dealer-Minded Organization"

Dearborn FARM EQUIPMENT

Symbol of Service
TO AGRICULTURE and INDUSTRY

For nearly 70 years De Laval has served the dairy industry well . . . and the name has long been a household word among farmers and dairymen. Thousands of De Laval Cream Separators are daily producing essential butterfat . . . and other thousands of De Laval Milkers are enabling dairy farmers to milk their cows with less help . . . and meet the staggering demands for milk.

And in almost every phase of industry De Laval Industrial Centrifugals are essential equipment . . . making possible entire production processes . . . affecting important manufacturing economies . . . and adding to the precision necessary to many quality products.

Literally . . . the name De Laval is symbolic of service and quality to all America.

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THE DE LAVAL SEPARATOR COMPANY

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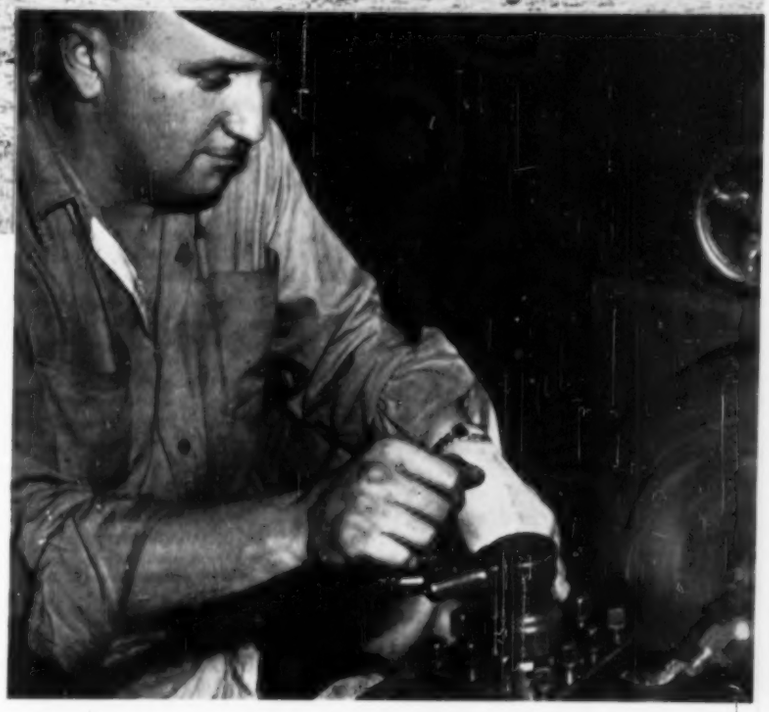

GRASSROOTS MECHANICS

Most of the men who build New Holland machines look a lot like farmers—and with good reason. Because a high percentage were born on farms and many still live there. On prosperous farms in the heart of Lancaster County, Pa., one of the richest agricultural counties in the nation. These farm-bred mechanics know how important it is to have the right kind of machinery at work on farms. They realize the machinery they build is designed to do complicated jobs—yet must be rugged for all kinds of farms everywhere.

That's why New Hollanders take pride and care in their work. That's why New Holland uses the latest improved manufacturing methods and machines. That's why 15 hours out of every 100 used to build Balers are spent on quality control—to make sure the machines are right for the job.

NEW HOLLAND MACHINE COMPANY

NEW HOLLAND, PENNSYLVANIA

FARM ENGINEERED MACHINERY FOR BETTER FARMING

MINNEAPOLIS-MOLINE
MM
MODERN MACHINERY

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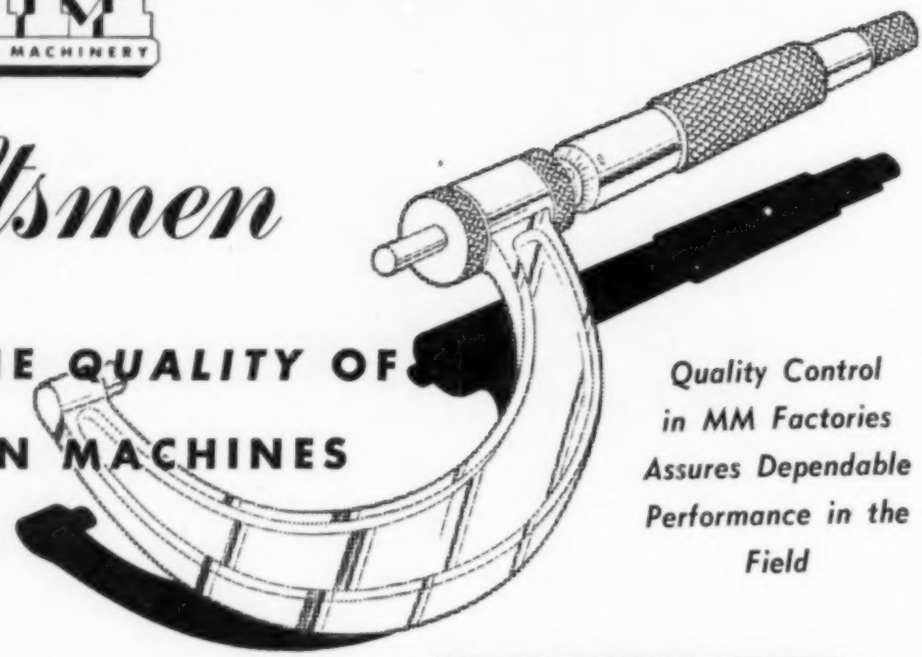

MAINTAIN THE *QUALITY* OF MM MODERN MACHINES

Quality Control in MM Factories Assures Dependable Performance in the Field

Years of Skill, Training, and Experience Help MM *Build Better Farm Machinery*

Experienced MM craftsmen, skilled in precision work and trained to turn out only the finest product, are maintaining the high standards of MM Modern Machines, Visionlined Tractors, and Power Units year after year. These MM employees represent a storehouse of skill, training, and experience that firmly supports MM's outstanding reputation for service and leadership wherever man tills the soil in the modern manner.

This storehouse of knowledge and skill is vitally necessary in the manufacture and distribution of modern farm machinery. And it is equally important that these skills be passed along to men enthusiastic and eager to aid the growth of a great modern industry.

The Proud Record of MM's *Employees and Dealer-Distributors:*

Of the approximately 6,500 employees, 890 or about 14% are Old-Timer employees with length of service records ranging from 20 to 59 years. Over 30% of our employees served with the armed forces in World War I or II. Of our dealer-distributor organization of some 2,000, approximately 10% have been MM dealers for over 20 years.

Minneapolis-Moline also takes deep pride in its father-and-son employee teams, now numbering 204, who are contributing to MM's reputation for skilled craftsmanship and high quality. The products of MM employees are now sold by 2000 dealers in this country and in Canada and by distributors in 30 different countries of the world. Many of these MM dealer and distributor set-ups are also father-and-son combinations. In some divisions over 20% of the dealerships are father-and-son organizations.

This record of loyal service is notable in a nation where free choice of work is a cherished privilege. To the Old-Timers, to the father-and-son teams, to all employees, dealers, and distributors, Minneapolis-Moline extends the wish that the years ahead will fulfill their fondest hopes.

AN MM EMPLOYEE SINCE 1890, Charles Beckman receives Old-Timer watch award from W. C. MacFarlane, MM president and general manager.

AN MM DEALER FOR 21 YEARS, J. T. McCarthy of Greeley, Nebraska is awarded an Old-Timer plaque from C. A. Johnson, MM Midwestern division manager.

AN MM DISTRIBUTOR FOR 53 YEARS, Douglas Malcomess, East London, South Africa receives his Old-Timer plaque from George L. Gillette, MM vice-president and general sales manager.

MINNEAPOLIS-MOLINE
MINNEAPOLIS 1, MINNESOTA

For a new thrill in radio— **at home or wherever you roam . . .**

New Zenith "Universal" PORTABLE RADIO

with exclusive "Tip-Top" Dial and Wavemagnet

HERE – from the world's leader in portable radios – is the most powerful standard broadcast portable in Zenith* history!

So sensitive is this stunning new Zenith "UNIVERSAL"* that it literally "reaches out" for distance. Brings in your favorite programs with amazing volume and tone beauty, even in places where many ordinary portables won't play!

The secret of this terrific performance is the stepped-up sensitivity made possible by Zenith's 3-Gang Tuning. Plus a new, more sensitive Zenith-built Alnico 5 Speaker that gives tone richness and clarity comparable to many console speakers!

The "UNIVERSAL" plays instantly when you open the lid, turns off when you close it. Lift the lid, and there's the giant "Tip-Top" Dial, actually *above* the set for easier tuning. Wavemagnet* built right into lid also swings up, away from signal-killing metal parts.

Plays on its own long-life battery, and AC or DC. Handsome, sturdy, luggage-style case in buffalo-grained black or brown. See this tremendous new value now, at your Zenith dealer's! Only $49.95†

Less Batteries

New Zenith "TRANS-OCEANIC"

New edition of the world-famous standard and short-wave portable with overall performance superior to that of any other portable. More powerful, more sensitive than ever – yet lighter, easier to carry, and lower in price. Brings in Standard Broadcast, plus International Short Wave on 5 separate bands. "Tropic-Treated" against humidity. Plays on thrifty long-life battery, and AC or DC. $99.95†

Less Batteries

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† West Coast and far South prices slightly higher. Prices subject to change without notice.

Over 30 Years of "Know-How" in Radionics* exclusively • Zenith Radio Corp., Chicago 39, Illinois

Also makers of America's Finest Hearing Aids

The Friendly Hand of Service!

Your every need can be filled here in Equipment, Furnishings and Supplies for Industrial Cafeterias and other Institutions.

Check Your Needs Now

IN EQUIPMENT, FURNISHINGS AND SUPPLIES

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- ☐ Bed Linens
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- ☐ French Fry Cutters
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- ☐ Plastic Tableware
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- ☐ Water Coolers
- ☐ Bar Supplies
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- ☐ Disinfectants and Germicides
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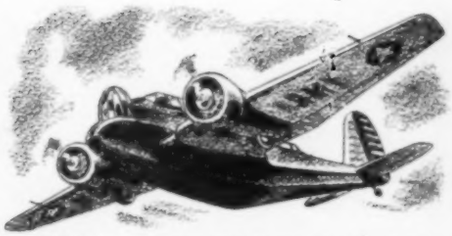
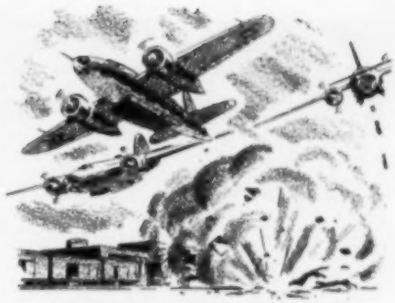
THIS WINCHESTER-ARMED 1913 PURSUIT PLANE WAS ANOTHER MARTIN FIRST! (IN 1918, A 37 MM. BALDWIN CANNON WAS MOUNTED EXPERIMENTALLY ON A FAMOUS MARTIN MB BOMBER.)



REVOLUTIONARY B-10 (COLLIER TROPHY) BOMBERS FEATURED THE FIRST ENCLOSED TURRET, A MARTIN DEVELOPMENT.

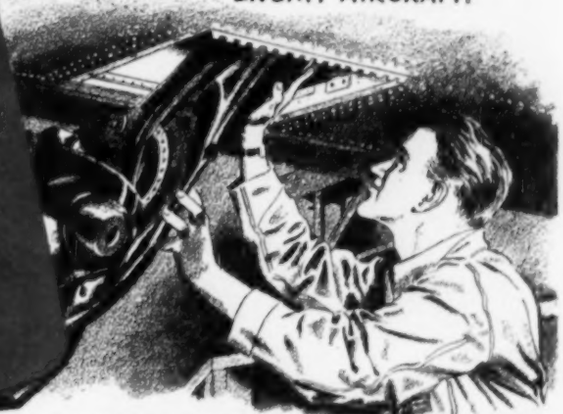


DURING WORLD WAR II, MARTIN WAS THE LARGEST BUILDER OF ELECTRICALLY-OPERATED GUN TURRETS.

IN 1936, MARTIN PRODUCED AMERICA'S FIRST POWER-OPERATED TURRET. **TODAY,** MARTIN ELECTRONIC FIRE CONTROL SYSTEMS MAINTAIN THIS HISTORIC LEADERSHIP. ELECTRONIC "BRAINS AND MUSCLES" TO LOCATE, TRACK AND FIRE AGAINST ENEMY AIRCRAFT.

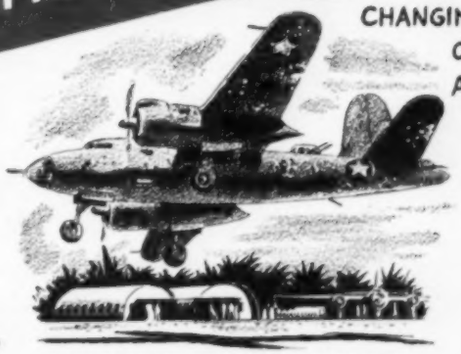
From Turrets and Tanks to Electronics and Elastomerics

Pioneering by Martin paid off here, too!

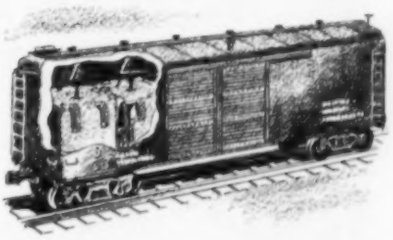


CHANGING A MARENG CELL IS A MATTER OF ONLY A FEW MINUTES' WORK--A VITAL FACTOR IN COMMERCIAL AIRLINE ECONOMY.

AS LONG AGO AS 1918, MARTIN EXPERIMENTED WITH BULLET-PROOF FUEL TANKS ON THE MB



THEIR SELF-SEALING FEATURE SAVED THE LIVES OF THOUSANDS OF AMERICAN AIRMEN AND HUNDREDS OF PLANES DURING WORLD WAR II



MARENG CELLS HELPED LICK TANK CAR SHORTAGE DURING EARLY MONTHS OF WORLD WAR II BY CARRYING GAS IN BOX CARS.

AMAZING MARTIN MARENG CELLS WERE DEVELOPED AS GAS TANKS IN THE LATE '30s TO FIT PLANE WINGS LIKE FOOTBALL BLADDERS.

Martin

AIRCRAFT

Builders of Dependable Aircraft Since 1909

Aerial gun turrets and versatile Mareng Cells (licensed to U. S. Rubber Co.) are typical Martin developments which have gone hand in hand with the building of a long line of great aircraft. In research and in the air, rely on Martin for results!

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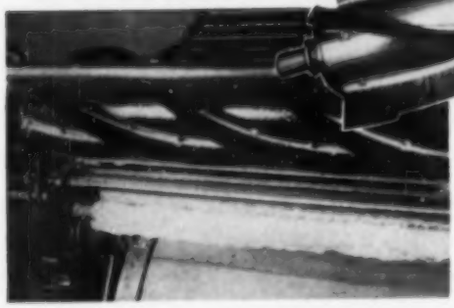

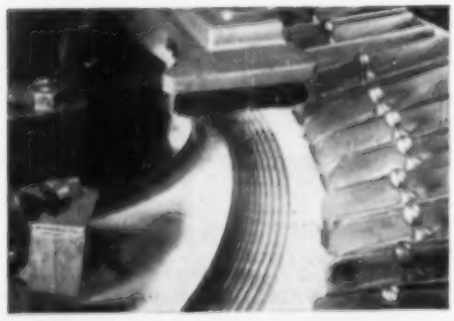

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Engineered for Your Specific Needs

Whatever your primary consideration — quality, price, or any other factor — you can get exactly what you want in Fullergript power-driven brushes.

Fullergript may be secured in a variety of materials and can be pre-formed in a variety of shapes. The brush material may be distributed along the metal backbone in heavy, medium or light densities and evenly distributed or tufted.

Fullergript, through its versatility and adaptability, lends itself to almost any brushing operation. Hundreds of plant owners have found that Fullergript saves them time and money in their automatic brushing operations.

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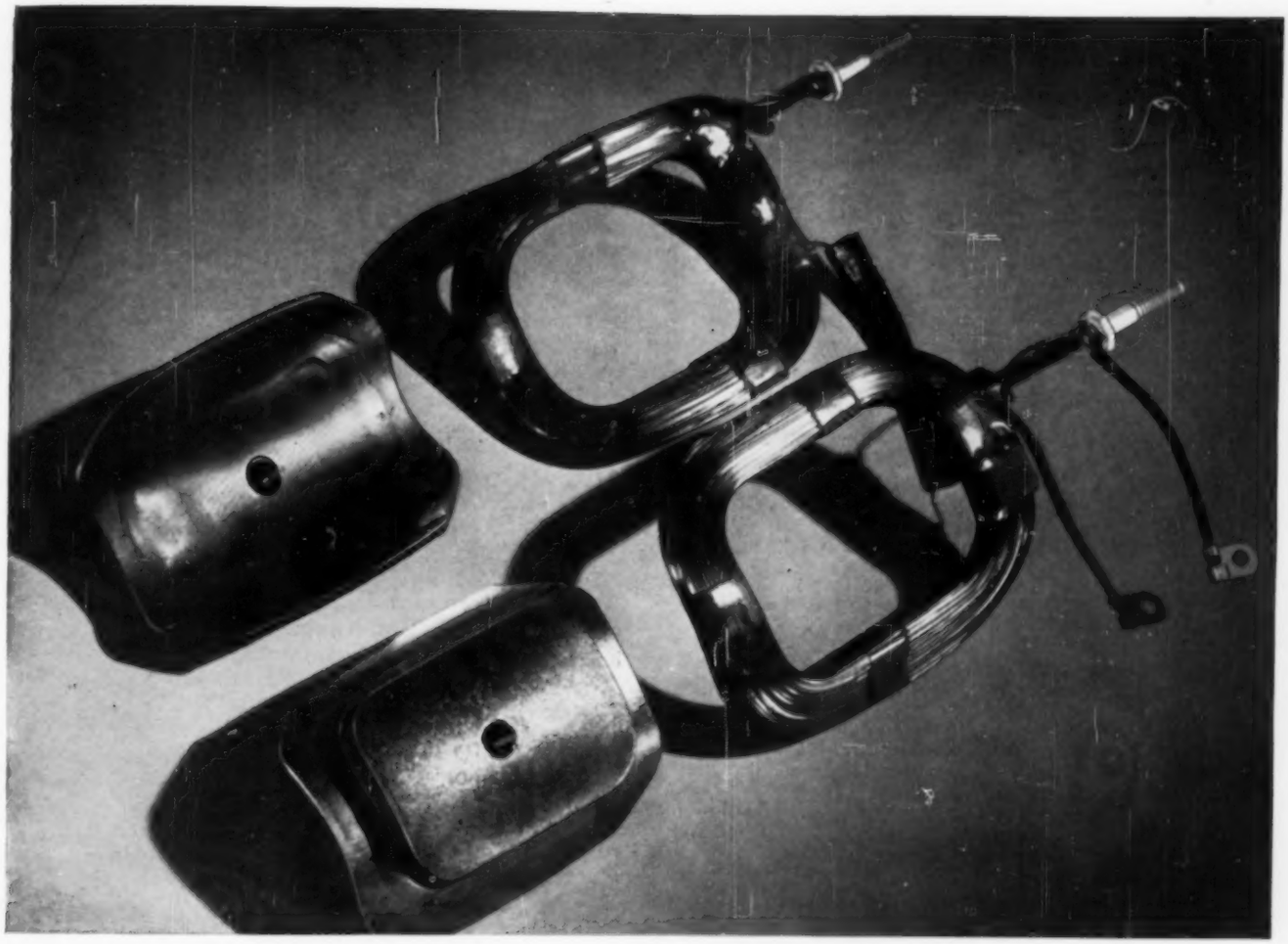

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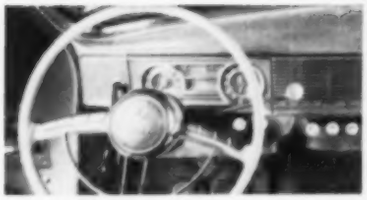
Better Performance

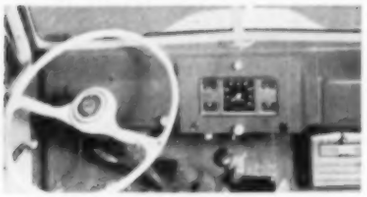
Two of the latest improvements in Delco-Remy production processes greatly increase the performance and durability of Delco-Remy generators. Newly designed pole shoes allow more room for field coil windings and shorter mean length of field coil turns. Plastic coated field coils are more compact, better insulated and longer lasting. Created through Delco-Remy's continuing program of research and development, these improvements provide added current capacity to meet today's accessory demand. They mark another Delco-Remy advance in design and manufacture.

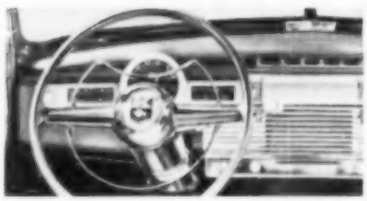
Delco-Remy

DIVISION, GENERAL MOTORS CORPORATION
ANDERSON, INDIANA

AUTOMOTIVE, TRACTOR AND MARINE ELECTRICAL EQUIPMENT







FIVE of the REASONS

for the Superiority of KS DASHBOARD INSTRUMENTS

King-Seeley electric dashboard instruments have long been superior in the automotive field because:

1. Their performance is always reliable—gives the car owner no cause for a gripe.

2. All connections are made with standard electric wire, thus they are easily installed by production line methods.

3. Holes in the dash are avoided. Engine noises are not telegraphed over the tubing to the dash which acts as a sounding board. Dangers and annoyance from broken tubes are eliminated.

4. The vehicle manufacturer can always depend on strict adherence to the delivery schedules of King-Seeley instruments.

5. King-Seeley research engineers are constantly searching for a way to improve the effectiveness, dependability, and economy of these instruments.

In the last seventeen years 50,000,000 K-S instruments have been installed in automobiles and trucks. For more detailed information, write to King-Seeley or ask for a representative to call.

KING-SEELEY CORPORATION

ANN ARBOR, MICHIGAN

PLANTS AT ANN ARBOR, SCIO, AND YPSILANTI

Quality Control, diligently and intelligently applied, has been a basic ingredient in creating, and constantly increasing, consumer acceptance and demand for Esterbrook pens.

Recent developments in statistical methods have made possible a consistent quality of product exceeding that of any period in our century-old history.

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AMERICA'S FIRST PENMAKER

on the highway and in the home

TIMKEN

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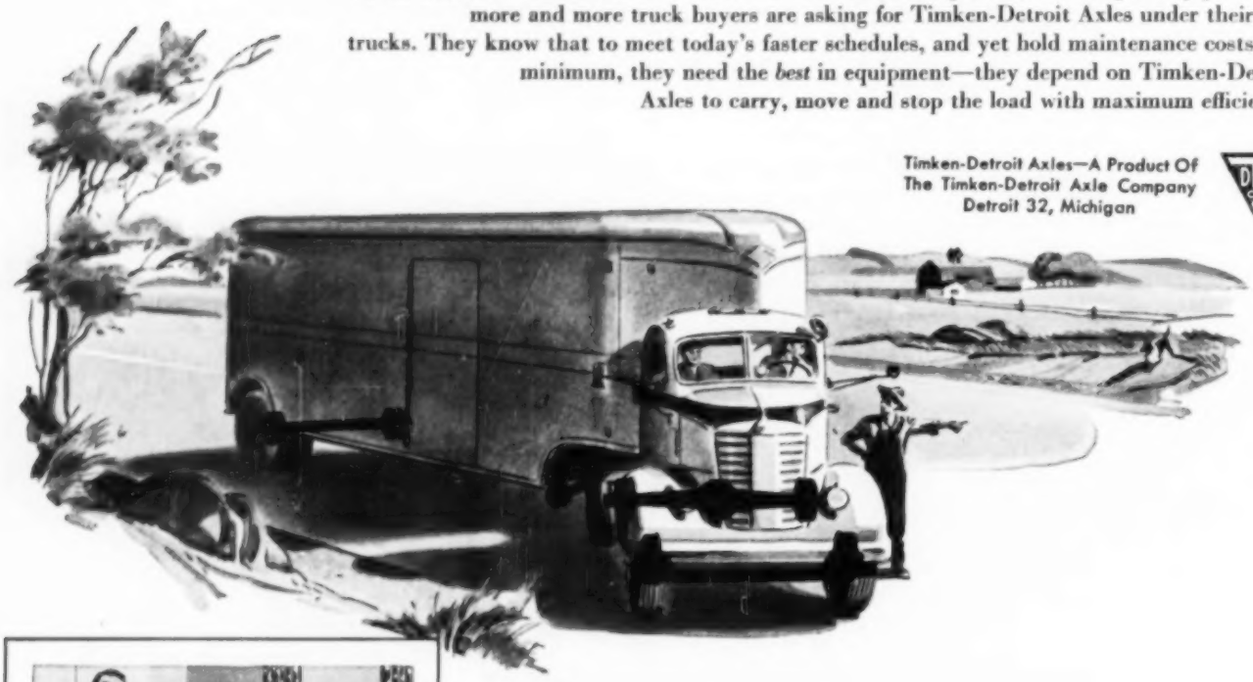
AXLE COMPANY

has been a quality leader since 1909

The finest of truck axles, for more than 40 years, have been those which bear The Timken-Detroit Axle Company's name. Some of the greatest engineering achievements in the industry—Hypoid Gearing, "3 for 1" Axles, Spring-Flex Power Shift, Full-Corner Housings, Dual-Primary Brakes—outstanding features of Timken-Detroit Axles—are products of the eight great Timken-Detroit plants.

Because of the number of these features—and the host of important advantages they provide—more and more truck buyers are asking for Timken-Detroit Axles under their new trucks. They know that to meet today's faster schedules, and yet hold maintenance costs to a minimum, they need the *best* in equipment—they depend on Timken-Detroit Axles to carry, move and stop the load with maximum efficiency.

Timken-Detroit Axles—A Product Of
The Timken-Detroit Axle Company
Detroit 32, Michigan



The finest of automatic heating equipment—designed and built by Timken Silent Automatic—has for 20 years made living easier, healthier and happier in hundreds of thousands of American homes. Timken Silent Automatic equipment comprises a wealth of product developments like the unique Wall-Flame Oil Burner, and a complete line of automatic heating equipment for oil, gas and coal.

Timken Silent Automatic Heat—Oil—Gas—Coal
Timken Silent Automatic Division
The Timken-Detroit Axle Company, Jackson, Michigan

PLANTS AT: DETROIT AND JACKSON, MICH. • OSHKOSH, WIS. • UTICA, N. Y. • ASHTABULA AND KENTON, OHIO • NEW CASTLE, PA.

SOLAR = Highest Quality Stainless Steel Products

IT'S ONE THING to design stainless steel parts or equipment and quite another to produce them . . . as many manufacturers have discovered. But today products that require the corrosion and high heat resistant properties of stainless . . small intricate parts . . . large sheets with complex curves and bends . . . complicated assemblies . . . all fabricated to amazingly close tolerances, are available as production items at Solar Aircraft Company, Des Moines, Iowa.

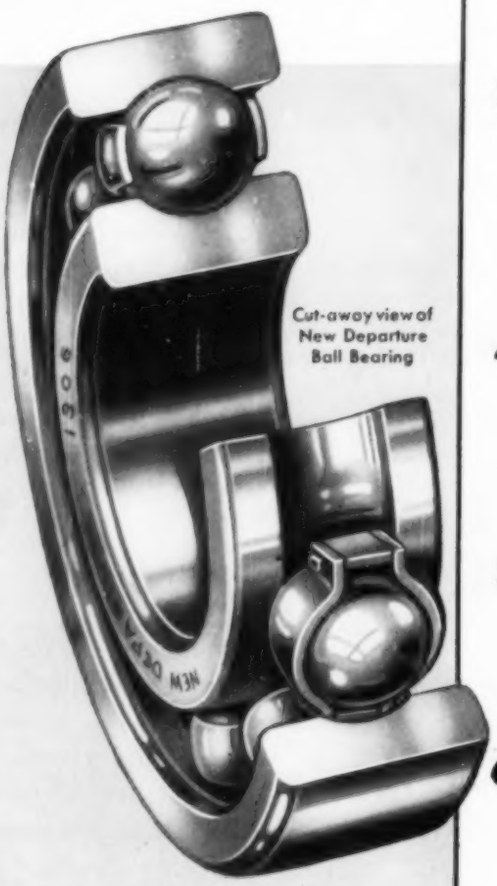
THE NAME OF SOLAR has been synonymous with the highest standards of quality manufacturing available in the stainless steel fabrication industry for the last 20 years. Continued improvements in manufacturing and inspection techniques are constantly investigated and developed. The Statistical Method of Quality Control has been found to be one of the most accurate and economical inspection means of achieving Solar standards.

SOLAR

Aircraft Company

SAN DIEGO • DES MOINES • NEW YORK

The bare facts about ball bearings



Cut-away view of New Departure Ball Bearing

Rugged New Departure Ball Bearings lick friction with free-rolling, tough, forged steel balls.

They welcome today's more exacting requirements of higher speeds, heavier loads and *continued* precise positioning of moving parts.

And . . . most important of all, New Departure, world's greatest ball bearing maker, meets your particular problems with a vast fund of experience and *original thinking*.

1

Nothing Rolls Like A Ball. It is nature's favorite, strongest form. Having no ends, it rolls freely in any direction.

2

Under heavy compression it deforms slightly and then resumes its original form. Made of the toughest, most resilient steel known to man, the New Departure steel ball is of uniform structure throughout.

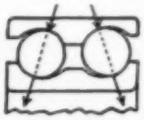
3

Its inherent resistance to load is greatly increased by curved raceways which, under load, are nearly filled by an arc of the ball. "Point contact" talk is the bunk. Actually, its contact is an ellipse, like this: ⬬

4

This is how a ball resists thrust (axial loads) as well as radial loads — like a bicycle on a banked track.

5

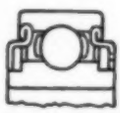


Put two rows of balls together, and you can support thrust and radial loads from any direction. They may be in one single bearing or in two separate bearings.

6

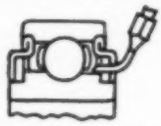
Unlike other types of rolling elements, the ball need not be forced to travel in the proper direction. Function of separator is merely to keep balls spaced. Contact is at poles (point of slowest rotation—least friction.)

7



Only ball bearings may be self-sealed with integral closures of felt and metal. In average conditions New Departures are lubricated for life. Other type bearings cannot maintain precise "inter-fitment" needed to maintain efficient sealing.

8



Newest new departure *by* New Departure: Lubrication in new sealed bearings may be revitalized by injecting with hollow needle on pressure oiler—without removal of seals or need for nipples, grease passages, plugs.

Nothing Rolls Like a Ball

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • Division of General Motors • BRISTOL, CONN. • Branches in DETROIT • CHICAGO • and Other Principal Cities

How Big is the CORE

of your POWER apple?

Densheath Type TW Building Wire with its special thermoplastic insulation is sound production insurance in any plant. It will not support combustion, is long-aging, impervious to acids, oils and alkalis. It is recognized by the National Electrical Code for circuits up to 600 volts and temperatures up to 140° F. . . . and for wet and oily locations. Being light weight, with a smooth, slick finish and without braid, Densheath pulls through easier . . . resists abrasion. Permanent, bright colors for quick circuit identification. Write for literature.

This is important, too—*for rewiring in existing raceways*, the Code recognizes the smaller diameter of Densheath TW and permits more conductors to be pulled in the same size conduit. Here is a typical case—

½" CONDUIT

Type R	Type TW
3 #10 Wires	6 #10 Wires

How MUCH of the electric power you pay for do you *throw over your shoulder* through overloaded, overextended, obsolete, inadequate wiring?*

Avoid wasting power. Find present losses and safeguard future expansion. Talk to your plant power engineer, consulting engineer, electrical contractor, wholesaler or utility power salesman. It's their job to advise and protect you against slow-downs and shut-downs that mean unproductive wages, lost production, spoilage.

***WIRE AHEAD** . . . a comprehensive discussion of preventive maintenance, points out the symptoms of inadequate wiring, presents detailed plans for anticipating electrical demand. Forty-eight factual pages of practical information and suggestions free on request.

ANACONDA
from mine to consumer

ANACONDA WIRE & CABLE COMPANY

25 Broadway, New York 4, N. Y.

WHEN THE SUN GOES DOWN...

Here at Guide Lamp, a lot of folks are at work to make driving safer, easier and less tiring . . . after dark.

You see the results of their research and craftsmanship in such fine accessories as the Guide spotlamp, with smooth-working inner controls . . . the Guide fog lamp for better visibility in fog, rain, snow and sleet . . . the Guide Glare-Proof mirror that "turns off" the glare from headlamps behind at a touch of the finger.

These, of course, are just a few of the many Guide products that have been improved and refined to keep pace with automotive progress. As the world's largest manufacturer of automotive and tractor lighting equipment, Guide Lamp builds Sealed Beam units, headlamps, tail lamps, parking lamps, directional signals and other accessory lamps for cars, trucks and buses.

When the sun goes down, Guide Lamp products "take over." Modern facilities and processes, as well as scientific quality controls, are standard operating procedures. Another way the folks at Guide Lamp make sure their products are the finest that can be built for the job.

GUIDE LAMP

Division of General Motors

ANDERSON, INDIANA

The Laboratories that work for us . . . both

The large buildings on the hill in New Kensington are actually your laboratories as well as ours.

Here we work out methods of producing aluminum to the high standards we know you want in the materials you buy. And the knowledge gained here is available to help you hold your quality at high levels also.

In our 62 years of making aluminum, we've worked out a lot of new ways to make better aluminum products . . . developed new alloys and scientific quality controls that are constantly reducing variations in our products and improving the average quality.

When you're setting up your assembly or manufacturing operations on aluminum products, we'll be glad to work with you, to make the most of the possibilities aluminum offers you. ALUMINUM COMPANY OF AMERICA, 1403 Gulf Building, Pittsburgh 19, Penna.

ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM ®

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ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

Hit-or-Miss Methods Are Out!

There's no compromise with quality at Harrison!

That's why over the years, leading manufacturers of hydraulic equipment have looked to us for the answers to their oil cooler problems. They know that Harrison oil coolers are developed by the most experienced design and engineering staff in the field—built by the largest producers of cooling equipment in the country.

Yes, every job—large or small—is carefully engineered, thoroughly tested and then manufactured under controlled processes by quality conscious operators. And to help customers get the fullest use out of every installation Harrison makes available a large service organization.

HARRISON
OIL COOLERS

HARRISON

HARRISON RADIATOR DIVISION,
GENERAL MOTORS CORPORATION, LOCKPORT, N. Y.

WHERE *Quality* COUNTS

In the construction field . . . with all the devils of adverse weather and unforeseen obstacles seemingly conspiring against him . . . the owner of Diesel-powered excavating and earth-moving equipment must often strain his equipment to the utmost to meet the deadline on a contract.

Far at sea and beset by storm and tide . . . perhaps loaded to the gunwales with a good catch . . . there's more involved than mere profit; it's a matter of life and death for the fisherman to make it safely home to port.

Drilling miles deep into the age-old strata of rock in search of petroleum on land or at sea, even a slight mechanical failure may mean the loss of a string of pipe, a "hole" and the thousands of man-hours and dollars invested.

To the Cotton Ginner, the Lumberman, the Strip Miner, the Tractor-Farmer, Irrigation Man and Truck Operator—to dozens of heavy industries where the economies and rugged power of Diesel engines are so vital, power failure may mean the loss of production at a time when such losses are hard to bear.

That's Where Quality Counts

That's where precision inspection and quality control in manufacture *pay off*. They pay off not only to the user of the product but through a growing reputation for dependability and a pyramiding of repeat orders they pay the manufacturer as well.

GM DIESEL POWER

DETROIT DIESEL ENGINE DIVISION

SINGLE ENGINES...*Up to 275 H.P.* **DETROIT 28, MICHIGAN** MULTIPLE UNITS...*Up to 800 H.P.*

GENERAL MOTORS

DIESEL BRAWN WITHOUT THE BULK

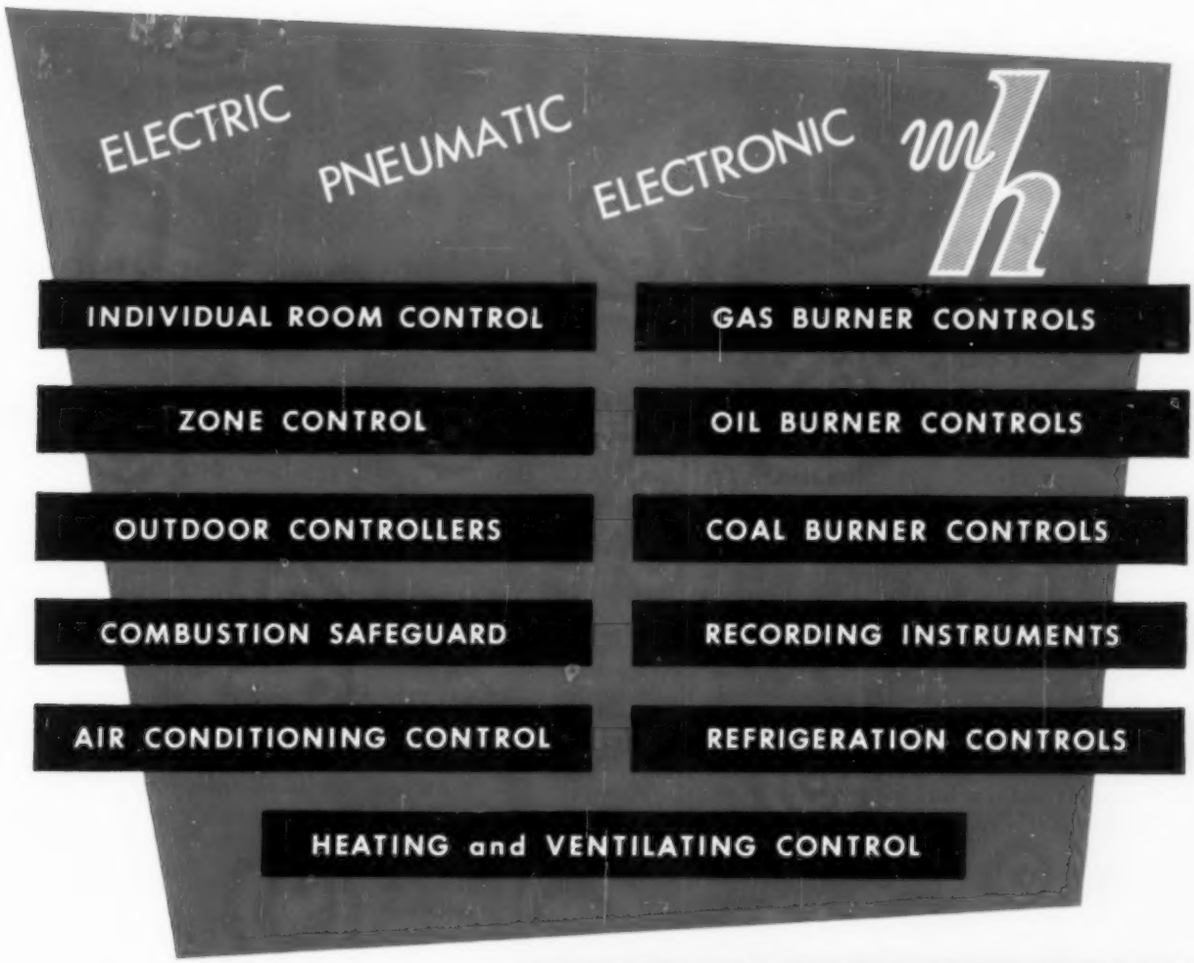
John Deere Men *Make the Difference*

John Deere is more than a name on green and yellow farm tractors and implements . . . more than shops and smokestacks. John Deere is a big family of skilled workmen, designers, dealers, and other specialists bent on manufacturing and marketing the world's finest farm equipment. Modern facilities, precision machines, and scientific quality controls are part of our stock in trade. We are old-fashioned enough, however, to believe that John Deere men—fellows who take pride in their work, who really try to excel at their jobs, who strive continually to give our customers greater value and better service—are the biggest single factor in our continuing success and growing service to American agriculture.

JOHN DEERE • MOLINE, ILLINOIS

Complete Line..... Complete Responsibility!

Only Honeywell Gives You Every Type of Automatic Control for Every Heating and Air Conditioning Need

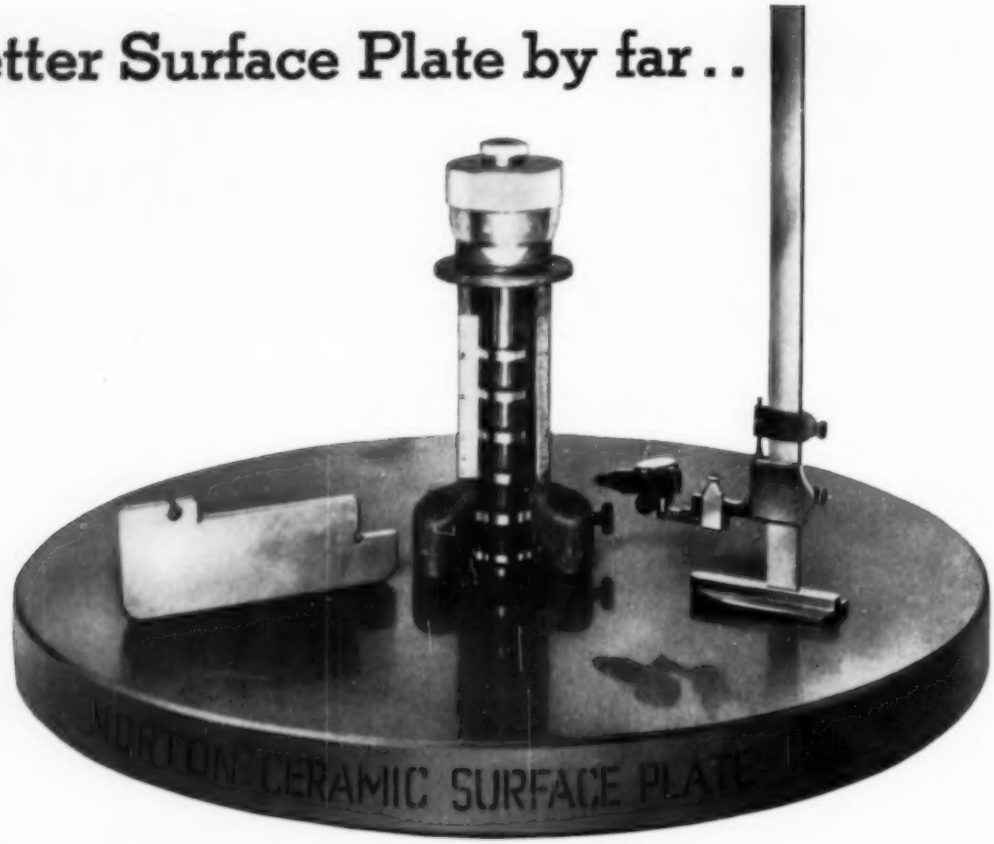


ONLY Honeywell offers a line of controls that's *complete*, for every type of installation in any building, new or old, large or small. So standardize on Honeywell. Gain the two-fold assurance only Honeywell can offer —undivided responsibility for all controls on the job, plus recommendations free from all prejudice. Put your confidence where you know it can be supported. Minneapolis-Honeywell, Minneapolis 8, Minnesota. In Canada: Leaside, Toronto 17, Ontario.

MINNEAPOLIS
Honeywell
CONTROL SYSTEMS

77 BRANCHES FROM COAST TO COAST WITH SUBSIDIARY COMPANIES IN: TORONTO • LONDON • STOCKHOLM • AMSTERDAM • BRUSSELS • ZURICH • MEXICO CITY

A Better Surface Plate by far . .



Better by far . . .

because it has so many superior qualities

CHECK THESE IMPORTANT QUALITIES and you'll see how Norton Ceramic Surface Plates will speed up precision checking and cut costs in your plant.

☑ ***LONG LIFE*** is guaranteed for these wear-resistant plates which are made of a material harder than any other type of surface plate. Laboratory and field tests proved wearability was 40 to 1 over best competing type.

☑ ***PRECISION FLATNESS*** of the Norton Ceramic Surface Plate has been found preferable for precision checking operations. Made of a durable and stable material, the ceramic plate stays flat. It will not warp or deform; it will not deflect under load.

☑ ***LESS WEAR OF EXPENSIVE INSTRUMENTS,*** gage blocks and sine bars has proved to be another cost-saving-feature of these ceramic surface plates. The continuously smooth surface allows easy movement of instruments and work across the plate.

NORTON COMPANY
Worcester 6, Massachusetts

☑ ***NON-CORROSIVE.*** The Norton Ceramic Surface Plate will never sweat nor corrode. It does not require greasing or protection from moisture.

☑ ***NON-MAGNETIC*** quality of these ceramic surface plates often proves to be another time-saving feature.

☑ ***LIGHT WEIGHT*** of Norton surface plates permits easy mobility from one checking operation to another. These plates can be finished both sides and their lightness permits easy turning for double utility.

☑ ***BETTER FOR BLUEING.*** The light colored surface of the Norton Ceramic Surface Plate reflects light better for blueing than do dark plates. The special surface texture permits a uniform film to be transferred from plate to work. The blueing mix spreads easily, is moist longer.

☑ ***LOWER MAINTENANCE COSTS*** are obviously the result of using these extremely wear-resistant plates which retain their precision surface finish through years of daily, severe use. The plate is easily cleaned with soap powder and water.

☑ ***CENTER HOLE FOR GAGE SHANK.*** The larger sizes of the Norton Ceramic Surface Plate are made with a center hole which in many checking operations is used to hold the gage shank or center post.

☑ ***FASTER, MORE ACCURATE READINGS*** can be obtained with this ceramic surface plate because the precisely flat and smooth surface permits accurate, duplicate readings to be made quickly.

For price information write for free Bulletin No. 1036

NORTON

CERAMIC SURFACE PLATES

Now Dialize Your AGD Snap Gages

Your AGD Adjustable Limit Snap Gage

STANDARD *Dializer**

Low Cost Dial Gage

**Easy to Install*

Remove a pair of pins from an AGD Adjustable Limit Snap Gage . . . install this new STANDARD Dializer . . . and you have an indicating DIAL SNAP GAGE! It's as easy as that . . . and far less expensive than buying an equivalent dial snap gage.

DIALIZER No. 1 for Frames 1 thru 6
DIALIZER No. 2 for Frames 7 thru 10
DIALIZER No. 3 for Frames 11 thru 16

★ ASSURES ACCURACY by use of *double* reed principle.

OUT of the LUXURY CLASS!

NO LONGER can you afford to be without the benefits of quantitative dial measurements. The STANDARD *Dializer* is priced way below an equivalent Dial Snap Gage. Even if you have to buy a new AGD snap to convert, you save on an overall basis.

★ EASILY INSTALLED in your AGD Adjustable Limit Snap Gages . . . any make.

★ CONVERTS any AGD Model — A, B or C, any size.

★ RANGE OF ADJUSTMENT is same as before *dializing*.

★ INDICATOR furnished with either .0001" or .001" graduations.

*Patent Applied For

STANDARD GAGE CO., Inc., Poughkeepsie, N.Y.

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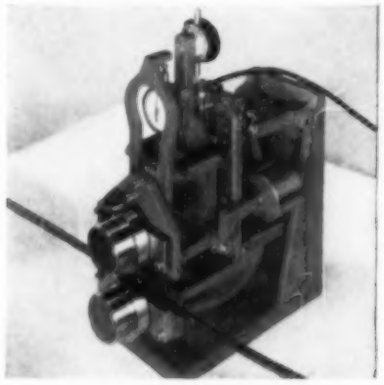
FEDERAL

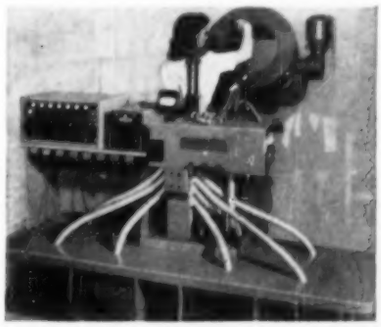
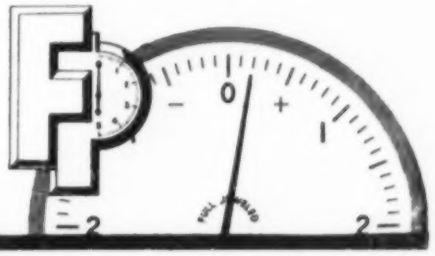
Largest manufacturer devoted exclusively to designing and manufacturing *all types* of DIMENSIONAL INDICATING GAGES

THREE CASES FROM THE FEDERAL FILE:

Federal Air Gage checks diameter and roundness of chrome plated cylinder bores — has upped inspection from 150 to 250 parts per hour. Gage is used at production to control plating process and reduce scrap.



Automatic Thickness Gage keeps continuous control of plastic coating deposited on copper conductor — saves materials — assures greater uniformity of insulated wire.



Electronic Sorting Gage segregates cylindrical parts into 4 OK diameter groups, over and under diameter groups, and over and under length groups. Speed — 3600 parts per hour. Diameter tolerances—.0001" per group.